Metabolomics and transcriptomics elucidate the mechanisms behind the detoxification and defence processes against ozone stress – insights from the birch and aspen studies

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BOOK OF ABSTRACTS

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All Division 3 (Forest Operations Engineering and Management) Meeting

107 - Collaborative logistics and planning in the forest sector

KG I - 1228 (Uni Freiburg)

IUFRO17-4001 **Routing of logging trucks in Norway**

Rönnqvist, M.* (1); Fjeld, D. (2); Flisberg, P. (3)

(1) Université Laval, Quebec, Canada; (2) NIBIO, Ås, Norway; (3) Foretry Research Institute of Sweden, Uppsala, Sweden

Abstract: Routing of logging trucks when many aspects are considered is difficult. A system called Calibrated Route Finder has been developed in Sweden and is currently in use. This project looks into the question if the same system is also applicable in Norway. There are a number of differences. One is the tariff system. Another is the road characteristic. There are many more mountains in Norway and the roads are steeper. We look into a process to test the Swedish system in Norway. We discuss some alterations and their advantages/disadvantages. We test on a number of collected preferred routes in Norway.

Routing, network, roads, transport, collaboration

KG I - 1228 (Uni Freiburg)

IUFRO17-512 **Balance Technical Efficiency and Harvesting Volume/Area at the Regional Forestry Timber Production**

Nitami, T.* (1)

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Abstract: In the business of regional forest utilization, the process condition grasping and the evaluation to decision making on business flow are inevitable for profitable forestry through the complex of multi processes and the compositions. ICT cloud system is useful to create the service system to support their tasks by functions. It is provided by the database on the site data, the operation data, the product data, data on the commercial flow, the transportation data, and so on, and the set of assistant tools for decision making through them. The framework composition and the function mechanism for introduce them above need us to balance equipping techniques and the production volume considering the regional forestry business maturity and the scale. Here it assumed to use a tower yarder operation to produce 50 m3/day/team, in a forestry region where final felling in 60 years and thinning in 20 and 40 years thorough sustainable circulating management, then we have the annual man-made forest operation around in 900 ha. A model to find the balance was discussed and the detail variation was studied when introducing thinning efficiency and so on.

harvesting, forest planning, machinery, balance

KG I - 1228 (Uni Freiburg)

IUFRO17-4166 **Potentials for developing geographical barter in Norwegian wood supply**

Fjeld, D.* (1); Rönnqvist, M. (2)

(1) NIBIO, Ås, Norway; (2) Université Laval, Quebec, Canada

Abstract: The practice of wood barter between procurement organizations is used to both balance supply and reduce transport costs. Barter between assortments and supply periods is used primarily to attain balance while geographical barter has been shown to potentially reduce transport costs by between 5 and 15 percent. The goal of this study was to examine the potential transport cost savings for geographical barter in varying topographies in Norway. Three case studies were made: i) direct flows of one assortment to three sawmills, ii) combined road and rail flows of one assortment to two main pulpwood markets, and iii) direct flows of four assortments to five sawmills. For direct flows in the most constrained topography the total potential cost savings was limited to 4 percent. For combined road and rail flows over a larger area the potential total savings varied between 11 and 13 percent. While restrictions for individual rationality prevented increased costs for any part, the suggested solution provided competitive advantage for only one market. For the final case of four assortments to five mills the savings varied from 0 to 10 percent between assortments. In this case, there were clear patterns of cross-flows of the same assortment generating mutual savings for both parts with easily identifiable areas for potential barter.

collaboration, transport costs, business models

KG I - 1228 (Uni Freiburg)

IUFRO17-1009 **Collaboration through standardization**

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(1) Université Laval, Quebec, Canada; (2) Foretry Research Institute of Sweden, Uppsala, Sweden

Abstract: Standardization is a powerful approach to enable collaboration. A standardized definition of log products enables wood bartering between two or several companies. This may lead to savings in the range 5-15%. Standardized distance measurement make it possible for transporters to work with several companies in a fair and transparent process. Best practice among stakeholders can be used to balance a range of conflicting objectives and support the most efficient routing to drivers. The weights are set through an inverse optimization process where detailed description of best practice is used as a baseline. The routes generated with the weighted objective aims to minimize stress, cost, fuel consumption, emissions and increase traffic safety. We describe such a system developed in Sweden which has been used since 2010 by the SDC, the logistic hub in Swedish forestry, and today is used by more than 60% of the overall 2 million transports done. We provide a description of some of the most important historical development of the system and how it is implemented at more than 100 companies. Today most contracts are based on the distance and special additions takes into account special considerations like hilly and curvy areas or extensive use of low quality roads. We describe a new standardized contract setting where the economic compensation is based on the resistance to drive along a route. This can be done using the developed system. Today thee is also an increased interest from all stakeholders to further focus on lowering emissions and consider different truck configuration with respect to gross weight limits. This also consider detailed analysis in terms of acceleration, braking and waiting at intersections. These developments and experiences are described in this presentation.

collaboration, transportation, routing, emissions

All Division 3 (Forest Operations Engineering and Management) Meeting

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KG I - 1228 (Uni Freiburg)

IUFRO17-811 **Hand Planter Ergonomics: Characterizing Physically Demanding Work in the Southeastern United States**

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Abstract: Low back and neck/shoulder musculoskeletal disorders (MSDs) are prevalent among reforestation hand planters. While previous investigations have documented the intense cardiovascular demands of manual planting, limited information is available regarding exposures to physical risk factors associated with the development of MSDs among hand planters. This study employed surface electromyography (EMG) and inertial measurement units (IMUs) to characterize the muscle activation patterns, upper arm and trunk postures, movement velocities, and physical activity (PA) of reforestation hand planters in the Southeastern United States over one entire work shift. Results indicate that hand planters are exposed to higher muscle activation patterns and more extreme upper arm and trunk postures and movement velocities than workers in several other occupational groups that commonly report a high prevalence of MSDs, including construction, automotive manufacturing, and healthcare workers. The findings indicate a need for continued field-based research among hand planters to identify and/or develop maximally effective intervention strategies and tools.

MSDs; posture; physical activity; muscle activity

KG I - 1228 (Uni Freiburg)

IUFRO17-3446 **Studying work in tropical forests: the need for integrative research approaches**

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Abstract: Social sustainability is a major issue of SFM, strongly based on ergonomically sound forest operations. Therefore ergonomic study and valuation are essential for development of forest operations. This commitment of work scientists is expressed with the motto "fitting the task to the human". An adequate work design is needed for forest operations in industrialized countries, but even more so in developing tropical and subtropical countries, where by trend working conditions are more severe and work even more heavy. Often forest operations, working systems and tools are less standardized. Introduction and use of appropriate technology are pivotal. Development of forest operations should be accompanied by stress and strain study, together with time study. But this is not sufficient. Ergonomists have to understand and integrate findings from other relevant disciplines, like rural sociology, regional research or development studies. Ideally interdisciplinary cooperation is done and research questions and methods are included into work study from the beginning.

In many countries we observe outsourcing, work done by contractors, not by employees of the forest enterprises themselves. This means that forest work science has to look on the specific characteristics of smaller or larger contracting enterprises, especially their working conditions as well as the underlying factors, at an operational level and in the societal environment. This must include all traditional tasks of forest work, like nursery work, planting, tending, pruning, harvesting, forest road construction and maintenance and also those connected with ecosystem services.

Research according to the traditional objectives and themes of work science, i.e. the design of work places and methods, will be continued. But the strategy of work science in future is oriented towards an inclusion of social and economic conditions as well as regional chains of added value into the sectoral research.

forest work, integrative work study, tropics

KG I - 1228 (Uni Freiburg)

IUFRO17-3114 **The Effect of Slash Reinforcement of Strip Roads on Rutting, Forwarder's Fuel Consumption, Driving Speed and Whole Body Vibrations**

Mohtashami, S.* (1); Jonsson, R. (1); Eliasson, L. (1); Ring, E. (1)

(1) The forestry research institute of Sweden, Skogforsk, Uppsala, Sweden

Abstract: Tree tops and branches, i.e. slash, extracted in final fellings can be used as forest fuel or to reinforce strip roads to prevent or reduce rutting. In a randomized block trial, fuel consumption, driving speed, proportion of strip road with rutting and operator's whole body vibrations during forwarding were studied when driving a laden forwarder on strip roads with and without slash reinforcement. The weight of the laden forwarder was 44 Mg. The study was carried out in south-central Sweden during fall 2014.

The driving on slash reinforced strip roads showed indications to lower diesel consumption compared with unreinforced roads. Driving speed and whole body vibrations was not affected by slash reinforcement. The proportion of rutting was 20 percent higher on roads without slash cover than on slash-reinforced roads and positively correlated with number of passages. Slash reinforcement increases the evenness of the strip road, and may thus affect both travel speed and fuel consumption. Travel speed is expected to increase and fuel consumption to decrease. However, as these factors interact, further studies of speed and fuel consumption are required.

logging operations, slash reinforcement, forwarder

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KG I - 1228 (Uni Freiburg)

IUFRO17-909 **A Biomechanical Analysis of Tropical Matang Mangrove Forest Operation Workers in Perak, Malaysia**

Gandaseca, S.* (1); Empawi, A. (1); Nyangon, L. (1); Achutan, K. (1); Jaafar, M. (1); Mohamad Pazi, A. M. (1)

(1) Department of Forest Production, Faculty of Forestry, Serdang, Malaysia

Abstract: The objectives of this study are to clarify physiological work loads and physical loads acting on the lumbar region of workers and to propose a safe work environment in tropical forestry operations. The research was conducted in the Tropical Matang Mangrove Forest, Perak, Malaysia. In this study, heart rates and the physical lumbar burden of mangrove forest operation workers were measured for three types of work, these are, felling-bucking and manual skidding. In addition, the load moment on the L5/S1 and the disc compression force were calculated using low-back biomechanical models. As a result, in the load moment on the L5/S1 disc, felling-bucking and human skidding were classified as very heavy and heavy, respectively. In the average compression force on the L5/S1 disc during felling-bucking and human skidding were estimated and found to be below the Action Limit (AL) by National Institute for Occupational Safety and Health (NIOSH). However, it was also found that some work posture types during felling-bucking by chain saw were sometimes above AL.

biomechanical model, forestry work, heart rate, lo

KG I - 1228 (Uni Freiburg)

IUFRO17-1235 **Assessment of heavy metal contamination in sediment along Sungai Sepetang, Perak**

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Abstract: Content: In Matang Mangrove Forest, there are numerous activities occur along Sungai Sepetang such as agriculture, fishery, timber and tourism. These activities may affect the sediment quality as there are many services provided around the mangrove forest at for nearby communities. Thus, this study was needed to be done in order to determine the heavy metal concentrations in sediment at Sungai Sepetang. Apart from that, these studies were also conducted to find if that any high heavy metal contamination of sediment along the river zone at Sungai Sepetang. The concentration of heavy metal was being compared for 3 different zones (upstream, middlestream and downstream) and 5 different depths (0-15 cm, 15-30 cm, 30-50 cm, 50-100 cm, >100 cm). As for each zone and depth, 75 sediment samples were collected using peat auger. This study was carried out by adopting standard methodology that was mostly used in previous studies of sediment contamination. The obtained data were analyzed using Statistical Analysis System (SAS) Version 9.2 to find mean comparisons between the zones and depths. As the result of heavy metal contamination assessment in sediment, it was determined that upstream has the highest amount of Lead 6.028 a(±0.758), Zinc 82.97a(±19.043)and Copper7.688a (±0.648).On the other hand , depth 1 (0-15 cm) has shown the higher amount of Zinc 84.46a (±34.130) Copper 7.707a (±1.172) and Iron 2428.53a(±23.33). In conclusion, sediment is one of the river component that has wide potential for heavy metal contamination. However, it is recommended for further research to be done in order to provide detailed findings for mangrove forest particularly on zones and depths.

Sediment, zones, depth, heavy metal, Mangrove

All Division 3 (Forest Operations Engineering and Management) Meeting

31 - Quality Assessments along the wood supply chain for optimal use of the forest resource

KG I - 1098 (Uni Freiburg)

IUFRO17-916 **Challenges in addressing merchantability of forest stands throughout the supply chain in the US Pacific Northwest**

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Abstract: Management of forests in the inland US Pacific Northwest (PNW) provides economic, ecological and social benefits. In many cases this management is predicated on value recovery of forest commodities removed. There are a variety of regional supply chain issues that limit merchantability and thus management options. 1) The forest resource is scattered and ownerships with differing management objectives are interwoven. 2) The forest products manufacturing base across all market levels is likewise dispersed. 3) A harvest typically generates a diverse mix of commodities which must be marketed to an equally diverse set of buyers. To address these challenges, this project first evaluates stand level merchantability issues and then incorporates those results into a spatial analysis of the PNW region. The resulting spatial analysis provides multiple regional maps highlighting merchantability hot-spots for both supply and demand. Supply hot-spot maps focus on the forest resource and indicate issues related to ownership, species composition, and age-class structure. Demand hot-spot maps focus on the forest products manufacturing base and indicate issues related to transportation, byproducts, and value recovery. The analysis provides useful information for targeting policy actions, public land management initiatives like Good Neighbor Authority, or investment opportunities to foster a nascent bioeconomy.

supply chain, merchantability, spatial analysis

KG I - 1098 (Uni Freiburg)

IUFRO17-1625 **New methods to estimate, analyze and map forest characteristics, wood quality and resources over large landscapes at high resolution**

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Abstract: The United States Forest Service has developed an object-oriented .NET library of tools for statistical and spatial analysis of natural resources called the RMRS Raster Utility. In this paper we present a case study illustrating a variety of novel statistical and computational techniques and tools that can be used to map forest characteristics, estimate wood quality and yield, and prioritize silvicultural treatments, as well as facilitate biomass procurement planning for bioenergy and bioproducts facilities. For a 20,000 km2 procurement area in Montana, USA, we used fixed plot inventory data and 1-meter color infrared imagery to map vegetation characteristics, including trees per acre, basal area, and above ground biomass by species. Then, using parameters associated with silvicultural objectives, we prioritized treatments across the region. Estimates of biomass removals were then linked to road data and regionally specific forest operations and logistics information to produce a facility-specific spatial gate cost model and procurement optimization routine with supply curves. Though we used the RMRS Raster Utility's free, add-in toolbar for ESRI's ArcGIS software, the methods presented can be replicated in almost any GIS environment, and can be applied to diverse, multi-scale spatial inputs to produce useful natural resource mapping, management and planning products.

Logistics, operations, GIS, spatial analysis

KG I - 1098 (Uni Freiburg)

IUFRO17-1390 **Defining the value of the stand using integrated LiDAR and multisource GIS data.**

Sanz Pareja, B.* (1); Malinen, J. (1); Leppänen, V. (2); Tokola, T. (1); Valbuena, R. (3); Kauranne, T. (4)

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Abstract: Prehas is a decision support tool developed by the Finnish Forest Research Institute for assessing the amount and value of harvestable timber, including predictions of timber assortment recovery, length-diameter distribution of logs and value recovery. Prehas-Finland, one of the versions of this software, can predict the technical quality affecting the bucking of the stems predicted from the stm-data by the MSN method; its bucking simulator can consider this predicted technical quality of the stems and produces timber assortment recovery estimates with or without estimated technical quality. The study area was located close to the municipality of Kiihtelysvaara (Finland). The main species in this area are Scots pine, followed by Norway spruce and a minor proportion of broadleaved species. The field survey data was a stratified sample with 79 square-shaped plots whose measurements were made between May and June 2010. The orthophoto was taken on 31 May 2009. The ALS data were collected on 26 June 2009, with an average point density of 11.9 pulses/m2. Metrics at grid cell level were computed over a regular grid of 25 m x 25 m cells covering the entire scanning area. Stands were delineated using ArboLiDAR and ArcGIS software. The stand delineation produced 67 stands which were distributed into 27 different properties; 36 field plots were located inside the produced stands. A complete tree list was estimated by means of ALS remote sensing. The method generated an estimation along the entire diameter at breast height and height frequency distribution at discrete 1 cm-wide diameter classes. The value of the estimated stem group was assessed by using the bucking-to-value simulator included in Prehas. The goal of this research is to present sound methodology for timber stand valuation, to be used either by timber buyers or sellers as a decision support tool.

Prehas; k-MSN method; value; quality; bucking.

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31 - Quality Assessments along the wood supply chain for optimal use of the forest resource

KG I - 1098 (Uni Freiburg)

IUFRO17-728 **Estimating external quality of stems for pre-harvest assessment of timber assortments**

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(1) University of Eastern Finland, Joensuu, Finland; (2) Natural Resources Institute Finland, Joensuu, Finland

Abstract: Pre-harvest information is needed for adjusting timber purchasing, pricing, stand allocation, bucking objectives and timing of forest operations to meet the needs of production using roundwood as a raw material. The information should include the volumes and qualities of sought timber assortments. For this bucking simulator fed by stem specific prediction for stand properties is essential.

The development of remote sensing methods together with computing methods offers possibilities to predict harvested volumes, timber assortment recoveries and length-diameter distribution of logs. Despite the importance, the prediction of external quality affecting on bucking and assortment recovery is still difficult and rarely considered.

Preharvest assessment software, developed for the purpose, is capable to produce stemwise prediction of harvestable stock based on previously collected CTL-harvester stem data (stm-data). These stems can be bucked by bucking simulator in order to produce timber assortment and log length-diameter recoveries utilizing case specific bucking objectives. In addition to dimension data, the software includes stem specific quality database with over 13000 stems measured for external quality. These data can be utilized for estimating external quality for stemwise prediction of harvestable stock. In the presentation, the methodology utilized and the results of validation of quality predictions are presented.

Quality, bucking, assortment, value, recovery

KG I - 1098 (Uni Freiburg)

IUFRO17-428 **Using acoustic tools to select for improved mechanical properties in a tree breeding programme for Sitka spruce (Picea sitchensis)**

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Abstract: In plantation forestry the wood supply chain starts with the selection of planting stock. Tree improvement programmes across the world have delivered improvements in the growth and wood properties of many species. In the UK a 50-year programme of selection and breeding of Sitka spruce, the main commercial softwood species, has enhanced growth rate and stem form while maintaining wood density. However, there has been little work to date on breeding to improve wood stiffness, a critical property in the mechanical performance of construction timber. In this study we report on the potential for using acoustic tools to screen for improved wood stiffness in the UK Sitka spruce breeding programme.

Two progeny trials planted in 1985 were selected for the study, each containing 61 full-sibling families. Diameter at breast height, Pilodyn pin penetration (indirect assessment of wood density) and acoustic velocity (indirect assessment of wood stiffness) were measured on standing trees. 30 families were selected for destructive analysis; clearwood stiffness and strength were measured in 3-point bending tests and wood density was measured using x-ray densitometry. A sub-sample of material was tested using the Silviscan instrument to obtain detailed pith to bark data relating to wood density, earlywood and latewood width, microfibril angle and cross-sectional tracheid dimensions. Correlations between indirect assessments of stiffness and density on standing trees and the destructive measurements made in the laboratory will be reported, together with correlations between and among the wood properties measured and their genetic parameters. The results of this study will inform future Sitka spruce tree breeding and help to deliver an improvement in the mechanical properties of future timber entering the wood supply chain in the UK.

KG I - 1098 (Uni Freiburg)

IUFRO17-4003 **Modelling wood quality of Douglas fir in France**

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Abstract: Douglas fir has become a species of increasing importance in France due to its fast growth and good wood properties (e.g., mechanical stability and durability). The objective of this work is to help define new and innovative forest management strategies in order to produce the resource for tomorrow and to meet the demand of the industry. A range of methods (including X-ray tomography) developed to assess wood quality of trees were applied to Douglas fir trees from four stands located in France and representing three age classes and contrasted thinning intensities. Several properties were analysed as a function of tree age and stand density: radial and vertical variations of wood density and moisture content, knottiness, stem taper and the amount of sapwood and its taper along the stem. For some of these properties, when possible with enough accuracy, predictive statistical models are proposed. In particular, a model for predicting the knot diameter profile and another one for predicting the sapwood taper are described.

basic specific gravity, water content

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KG I - 1098 (Uni Freiburg)

IUFRO17-1994 **Accuracy of knot end point detection in CT images of Douglas-fir logs**

Longo, B. L.* (1); Brüchert, F. (2); Becker, G. (1); Sauter, U. H. (2)

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Abstract: Due to climate change Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) has been presenting a large potential concerning wood utilization in Germany, therefore regarded as an alternative to spruce. Considering its vigorous increment, many trees have been pruned to increase the wood quality. Thus, it is primordial to identify where a knot ends, in order to optimize sorting procedures and predict the amount of wood free of defects. As an asset in knot quantification, computerized tomography (CT) is increasingly being used as a non-destructive method to detect and measure knots. Hence, this study aims to apply the algorithm developed by Johansson et al. (2013) and evaluate its accuracy in detecting the knot end point in CT images of Douglas-fir logs. The material is composed by 6 trees at the age of 78 from south-west Germany. The knots were randomly selected, considering full and pruned knots throughout the stem length. As a reference method for validation, the knots were also measured on physical samples. Preliminary analyses indicate that despite having a significant correlation between the methods, there are still uncertainties, which may be due to the lower contrast between the knot and its surroundings in the sapwood area. Therefore, further investigation is recommended.

X-ray scanning, clear wood, algorithm validation

KG I - 1098 (Uni Freiburg)

IUFRO17-4017 **Impact of partial cutting on sawmill profitability in the eastern boreal forest of Canada**

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(1) Université Laval, Québec, Canada; (2) Northern Arizona University, Flagstaff, United States

Abstract: The eastern boreal forest of Canada is characterised by long return interval of severe, stand-initiative forest fires. Under these principles of ecosystem-based management, the natural disturbance regime prevailing in this region demands a more frequent use of partial cuts. Increased harvesting costs currently restrain the use of partial cuts in commercial operations, especially in the context of the limited profitability of a value chain that relies on the harvesting small stems close the to the northern limit of productive forests. However, the added mill productivity resulting from the selection of the largest stems of a stand in thinnings 'from above' has rarely been assessed. The main objective of this study was to evaluate the financial benefits associated with the processing of stems supplied from partial cuts in various stand types of the eastern boreal forest of Canada. The software platform Logilab was combined with the sawing model StatSAW to perform simulations aiming at the maximum profit for a mill with a productivity of 300 000 m3 / year. Results showed that the supply from partial cuts generated higher profits at the sawmill in 19 of the 24 analyzed stand types. The maximum increase of $ 3.00 per m3 of round wood was reached in old uneven-aged forest dominated by balsam fir accompanied by black spruce. The average increase for the 19 stands was $ 1.12 per m3. Such added profitability in the sawmill should be considered when assessing the overall cost of partial cuts along the whole forestry wood chain.

Partial cuts, forestry woodchain

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154 - Sustainable and Constructive Strategy of Ergonomic Research in Forestry

K9 (Konzerthaus Freiburg)

IUFRO17-1681 **Study courses on forest ergonomics aiming at basic competences - examples from the University of Freiburg**

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Abstract:
Forest Ergonomics (Forstliche Arbeitswissenschaft) has traditionally been a study subject in the forestry programmes in Germany. This presentation focusses on ergonomics courses held in the 1995 study programme. The one week course on stress and strain is used as an example of working for basic students' competences in ergonomics. Other work study courses dealt with projects on wage systems, occupation related legislation, exploring the labour market for graduates, social science and gender aspects of forest work, mostly dealing with forest work in Germany, sometimes with forest work under tropical conditions.

The course objectives were achievement of knowledge of work study methods (time, stress and strain study), the ability to execute such studies, but also affective orientation. This course used pruning of forest trees as example, with many short work cycles, as a minimum number of cycles has to be evaluated to make the study meaningful.

Compact courses like this allow didactic approaches following the learning paradigm in a methodically inherent way, working on practical tasks. They allow students to achieve the competences they will need in their future work because the tasks are close to reality of working life. Students enjoyed the change between classroom and field work.

K9 (Konzerthaus Freiburg)

IUFRO17-4167 **Perspectives on forest ergonomics**

Heinimann, H.* (1)

(1) Future Resilient Systems, Singapore-ETH Centre, Singapore, Singapore

Abstract: Ergonomics as a scientific discipline emerged to solve worker health and safety issues, which still are important in the work systems that are labor dominated. Mechanization shifted the focus to man-machine interface design, and automation has been replacing supervision, control and cognitive functions, which moved the interests of ergonomics to socio-technical systems. By the end of the 1990s, a paradigm shift moved ergonomics into a new area that is characterized by "distributed cognition". Proponents found evidence that any type of social group - crew, team, department, etc. - has a joint capability to keep awareness high, to anticipate disruptions, to retrieve patterns of action that proved to be useful in the past, and to implement preventive or corrective actions. "High reliability organizations (HRO)" is one corresponding stream of research, while "resilience engineering" is a second one.
The presentation aims to (1) characterize the essence of the HRA and resilience engineering approaches to ergonomics, and to (2) discuss if and how those new approaches could be useful for forestry. The interesting thing is that the investigation of a forest fire fighting disaster of 1949 - resulting in the death of 13 firefighters - was one of the starting points of the high reliability organization conceptualization. The challenges are how to introduce the set of thinking, covering the range from "health and safety" to "distributed cognition" into forest education and practice, and how to shape organizational factors that are contributing to high reliability behavior.

High reliability, ergonomic concepts

K9 (Konzerthaus Freiburg)

IUFRO17-421 **Analyzing OSH Problems in Indonesian Forest Operation: A STAMP-System Dynamics Approach**

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Abstract: The problem on occupational safety and health, work productivity, and comfortability in the forest operation has been emerged as a global issue since last decades. Taking Indonesian forest operations as the object of this study, we try to propose the strategy in promoting a good man-work environment interaction, especially in the occupational safety and health. This study covers laws, regulations, responsible bodies, its tasks and roles, and interaction among them, not only at national level but also at the working group level. Considering this scale, we use a STAMP analysis together with system dynamics approach as they can examine the role of each component, the control line, the feedback and information flow. This study shows the position of current OSH control structure compared to the theoretical control structure. The combination is also able to identify many exogenous variables that act as levers on the system behaviors. In the end, the study offers strategies in organizational and policy design.

policy design, control structure

All Division 3 (Forest Operations Engineering and Management) Meeting

154 - Sustainable and Constructive Strategy of Ergonomic Research in Forestry

K9 (Konzerthaus Freiburg)

IUFRO17-1690 **Development of ergonomics in Polish forestry**

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Abstract: The development of ergonomics in Poland can be basically dated since 1964, when the first national Ergonomic Section was founded. The following milestones were reached in 1970's, when a number of institutions emerged, including the Ergonomic Commission of the Polish Academy of Sciences (PAS)(1972), the Committee on Ergonomics of PAS (1974),and the Polish Ergonomics Society (1977). In 1968 the first Polish handbook entitled "Ergonomics. The issues of human adjustments to work" (by Jan Rosner), was published. However, the history of ergonomics in Poland is far much longer, associated with the activity of Prof. Wojciech Jastrzebowski. He was the scientist who defined the term of ergonomics as a scientific discipline concerned with work, for the first time in the world, in 1857. In Polish forestry the science of ergonomics was introduced on three faculties of forestry as early as in 1960's. At the beginning of 1980's the Faculties of Forestry in Krakow, Poznan and Warsaw started giving lectures on "Ergonomics and labor protection"). We owe the greatest achievements in the field of ergonomics in forestry to the following scientists: J. Fibiger, J. Józefciuk, K. Rogalinski, Z. Muszynski, and J. Bielski, J.Sowa and D.Giefing. Presently, the issue of ergonomics in forestry are conducted by the third generation of teachers: W. Nowacka, W. Grzywinski, and K. Leszczynski. Amongst the major scientific and research achievements in the scope of ergonomics in Polish forestry one should name papers and monographs concerning the ergonomic optimization of technologies of forest works, minimization of physical and mental workload on worksites in forestry, model studies on reducing the work arduousness and improving the comfort and safety of work. Summing up, Poland is undoubtedly a country where the science of ergonomics dynamically develops. A great number of Polish forest ergonomists actively participate in proceedings of international scientific and research communities.

Poland, forestry, ergonomics, development

K9 (Konzerthaus Freiburg)

IUFRO17-2136 **Mechanization in forestry and benefits at the local level. Polish study**

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Abstract: This study analyzes the interrelationship between mechanization in Polish forestry and local communities benefits. Local benefits are defined by this study as outcomes that, directly or indirectly, have positive influence upon people and families living within or nearby forests.
In view of the nature of the issues studied, quantitative field research methods, including structured interviews and questionnaires were used to supply detailed data. Studies were developed at two levels: detailed case studies based on two questionnaires and literature, documentary analysis.
Mechanized wood harvesting is fast developing in many former planned economies East Europe Countries. In Poland strong and lasting mechanization of wood harvesting has started almost two decades ago and rapid growth is noted. The fast growing mechanization of forestry in Poland is perceived by rural communities with a great interest. It is one of the leading forces of local growth. Research indicates that forest is a source of family growth and improvement for 75% of respondents. Forest is a place of employment for almost half of investigated families (one or more person employed in forestry). The diverse of benefits is described based on possessed questionnaires and literature survey.

mechanization, ergonomics, local communities

K9 (Konzerthaus Freiburg)

IUFRO17-2326 **Sustainable and Constructive Strategy of Ergonomic Research in Forestry**

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Abstract: Around forest and forestry, new technologies and concepts have been realized for last decade. Especially, the evolution of ICT (GPS, LiDAR, GIS, UAV, and so on) is remarkable and has contributed greatly in forest and forestry. Moreover, new utilization of wood (CLT, cellulose nanofiber, and so on), energy use of wood (bioenergy, bioethanol, and so on), improvement of wood supply-chain, ecological service of forest, social benefit of forest, and forest certification are changing conventional concepts of some regional forest managements. According as those new movements, ergonomics had better expand its research sphere. In this report, I will present new sphere which future ergonomic research had better include, and propose a content of world standard ergonomic textbook.

ergonomics, strategy, future concept, textbook

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K9 (Konzerthaus Freiburg)

IUFRO17-2798 **Physiological workload at forester and deputy forester workstations in Poland**

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Abstract: Forester and deputy forester are two the most numerous workstations in forestry in Poland. Both workstations are occupied by about 10.5 thousand employees in State Forests in Poland. They are response for planning, organizing and supervising of all technological and administrative activities in forest district area. The aim of the study is recognition of physiological workload at these workstations, its variability in different stages of forest district difficulty and in particular seasons of a calendar year. The study was carried out on over 400 foresters and deputy foresters in the whole country. On the ground of the newest classification of economic difficulty of forest districts (the main factor of this classification is the volume of timber harvesting) they were divided into 3 categories: (1) - easy, (2) - moderate, (3) - difficult. The study was conducted in a forest district with two-man cast: forester and deputy forester. Physiological workload was evaluated on the basis of constant heart rate (HR) measurement with the Polar H7 and accelometer AciGraph GT9X. In the paper there are presented the average values of HR in particular seasons of a calendar year and in the whole year. Total physiological workload was also analyzed in relation to the stage of forest district difficulty.

forester, deputy forester, workload, HR rate

K9 (Konzerthaus Freiburg)

IUFRO17-1400 **The course of physiological functions in connection with listening to selected sounds**

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Abstract: The main objective of the study was to find relations between the listening to selected acoustic stimuli and the course of physiological functions in 52 examined persons. Studied were also differences in the subjective perception of the sounds. The acoustic stimuli were 7-minutes lasting records of the sound of chainsaw in operation and of the typical sound in the forest (rustling of leaves, blowing of wind). Physiological functions were: abdominal respiration, thoracic respiration and their amplitude and frequency, electro dermal activity, body temperature, heart rate (total blood pulse, blood volume pulse, blood volume amplitude) and motility. The values of blood volume amplitude measured in the individuals exposed to the sound of chainsaw were markedly lower than the values observed in the individuals listening to the sound of forest. The examined persons listening to the sound of chainsaw also exhibited a higher rate of homogeneous distribution (lower variance) of the values of this physiological function. Mean values of physiological functions from selected time intervals were compared too. The course of most physiological functions briskly changed in both groups within 210 - 240 seconds from the start of measuring, this showing most in abdominal respiration, skin conductance level and blood pulse. On the other hand, some of the functions such as blood volume amplitude, thoracic respiration and body temperature exhibited significant changes already after 70 - 90 seconds. The results indicate that the course of physiological functions is more determined (modulated) by the sound of chainsaw. Differences in the subjective condition of probands were analyzed both in connection with the comparison of sounds themselves and separately prior to and after the exposure. The probands felt that their capacity of memorizing and learning improved after exposure to the sound. By contrast, the persons exposed to the sound of chainsaw felt more tired than before the exposure.

physiological functions, acoustic stimuli, sound

K9 (Konzerthaus Freiburg)

IUFRO17-2028 **Eye-tracking studies - new opportunities in analyzing work processes in forestry**

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Abstract: Analyses of eyeball movements (eye-tracking) are employed, i.a. in developmental psychology, cognitive science, medicine, Human-Computer Interface systems. This research aimed to establish the possible applications of eye-tracking in analyzing logging processes, and covered worksites of harvester's operators, more and less experienced, working in mature and thinned pine stands. The studies were conducted using the Tobii Pro Glasses 2 analyzer, and included analyses of eye scanpath, areas of interest, variability in duration of eye focusing (fixations), and eye shifting between the successive points (saccades). The level of work experience was reflected by the number of saccades and regressions (eye shifting back to the previous point), greater while examining less experienced operator. Varied work experience was also legible in different visual scenes. During cutting operations more experienced operator put more attention to the material being processed. Less experienced operator focused his sight also on upper parts of trunks, crowns and a harvester head. Variable duration of fixations and saccades indicated various behaviors of operators determined by their experience, difficulty of operations and readiness to work. Eye-tracking may significantly complement standard physiological methods of worksite analysis, since it records not only the outcome of operations performed, but also the manner of their performance.

ergonomics, eye-tracking, logging, harvester

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169 - New comminution technologies and logistics to improve the quality of forest energy feedstock

K 2-4 (Konzerthaus Freiburg)

IUFRO17-426 **ISO standards for solid biofuels and their application in practise**

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Abstract: Standards have been developed first in Europe (CEN) and on this basis in ISO. Standards exist for terminology, requirements and classes, quality requirements, measuring methods, sampling and sample preparation, health and safety and quality assurance.

The requirements and classes standard (ISO16225) describes in detail what quality demands there are on a long list of solid biofuels, such as wood pellets, wood chips, briquettes and firewood.

Quality assurance and certification are rather common for wood pellets (DIN+ and EN-plus), but rarely seen for other fuels like wood chips and firewood.

The Wood Fuel Quality Assurance scheme in Ireland seeks just to do that. Each participationg company must write their own handbook and keep a ledger of their own measurements and these are checked at irregular intervals by an independent certification body. Sofar 16 companies have joined the WFQA scheme:only one for wood pellets, 11 for firewood and 6 for wood chip. Some companies have been certified for more than one fuel.

Conclusions:
ISO standardisation facilitates world trade of solid biofuels by laying down quality requirements as well as defining measuring methods and terminology

Using standards also helps in quality assurance

As far as known, Ireland is the only country that offers certification for other wood fuels than wood pellets. The WFQA offers certification for wood chips, firewood , wood briquettes and wood pellets

standardisation, certification, wood fuel quality

K 2-4 (Konzerthaus Freiburg)

IUFRO17-92 **Managing knife wear and chipper settings to increase productivity, fuel efficiency and product quality**

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Abstract: The competitive capacity of forest biomass depends on the ability of producers to minimize production cost, while maximizing product quality. Improvement efforts can be directed towards two main areas: operational planning and machine setting. With regards to the latter, operators may manipulate target chip length and knife replacement schedules to best effect. It has been convincingly shown that increasing target chip length may result in a productivity gain of 20 to 30%, and in a reduction of fuel consumption up to 50%. Timely replacement of dull knives brings even larger gains, which has been demonstrated in several studies, both observational and controlled. Furthermore, latest chipper models feature new hydraulic in-feed and evacuation systems that can be adjusted on the fly to match variable work conditions. Proper adjustments of the in-feed and evacuation systems may accrue significant benefits in terms of increased productivity, reduced diesel fuel consumption and better chip quality. In particular, decreasing blower speed when full ejection power is not necessary allows reducing diesel fuel consumption by over 10%, while increasing chip integrity by 20%. This presentation will offer a comprehensive and articulate review of previous studies on the subject, thus providing quantitative information about the significant efficiency and quality gains that can be obtained from proper manipulation of chipper settings.

chipping; fuel; biomass; precision; diesel

K 2-4 (Konzerthaus Freiburg)

IUFRO17-756 **Finite element analysis to predict in-forest stored harvest residue moisture content**

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Abstract: The importance of wood moisture content to increase wood's economic value for bio-energy production has been recognized by researchers. Focus has been given to small logs and predicting models include methods such as heuristic fitting and multiple regression. Finite element analysis (FEA) is a method that allows determining drying rates while offering the flexibility of changing how these residues are stored, their shape and location, material properties, and drying seasons. FEA was used to develop drying rates for four different Oregon climate regions and three conifer species. An innovative measuring protocol was implemented in the field to asses these models. Statistical tests show model agreement with correlations between 0.56 and 0.92 in all sites. After performing sensitivity analyses, we can conclude that selection of pile shape or size can be beneficial or detrimental towards drying depending on ambient conditions. Windrow is the shape that mostly promotes drying in the summer and re-wetting in winter. It is best to reduce pile size to facilitate drying in summer, and increase pile size if material will be left in the field during winter. Drying times can be reduced by 1/3 if the material is cut and left drying during summer months versus winter.

Moisture, finite element analysis, harvest residue

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K 2-4 (Konzerthaus Freiburg)

IUFRO17-1817 **Chipping productivity, cost and product quality of logging residue by extraction methods**

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Abstract: The timber harvesting cost in South Korea is increased because of high labour and the acquisition and transportation costs. Meanwhile, the log price in forest did not go up, and this is the main cause of difficulties of forest management. There are plenty of biomass reserves available in the forests of South Korea, but only a small part of the potential is used at the moment. New biomass business like wood pellet plant and boiler have created by Korea Forest Service in the last 8 years. But, there are still remain problems of biomass feed stock supplying due to high acquisition, transportation costs and low heating oil prices. As a result, cheaper woody fuels than wood pellet that can be produce low costs is required in South Korea. In this study, we compared the effect of extraction methods for logging residue on chipping productivity, cost and product quality. Tests were conducted on three logging residue, produced through cut-to-length (CTL), tree-length log (TLL) and whole tree (WT) harvesting system. This study showed a similar chipping productivity and cost for all types of logging residue tested in terms of same working conditions like screen size, blade wear, operator and so on. Ash content, size distributions, and contamination related in chip quality is under test. We will report these results to session meetings. Further studies should determine the effect of blade wear on the relative quality of the three logging residue types.

comminution, logging residue, woodchip quality

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1025 **Evaluating the performance of star and deck screen machines separating biomass feedstocks**

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Abstract: The most commonly traded forms of biomass energy feedstock are wood chips and hog fuel. Particle size distribution is one of the key characteristics that affect efficient feedstock handling and biomass conversion. This research compares a star and deck screen machine productivity and effectiveness at separating wood chips and hog fuel into three different size categories: under (< 10 mm), accept (10 - 51 mm), and over (>51 mm). To reduce diving problems, the deck screen machine tested with two different top screens setting options (SS1- 4 sets of 51mm screen; SS2 - one 19 mm and 3 sets of 51mm screens). This study indicated that the star screen (62.61 and 50.95 tons/hour) was more productive than the deck screen (26.80 and 15.63 tons/hour) with wood chips and hog fuel, respectively. To apply screening systems, there was additional operation cost is required $3.53/ton and $6.05/ton for deck screen and $1.61/ton and $1.98/ton for star screen with wood chips and hog fuel, respectively. As a result of different settings of deck screen, there was a significant reduction in the presence of oversized material in the accept size class (>51 mm size materials reducing from 3.2% to 0.5%). Also, SS2 settings resulted in higher screening accuracy (83.8%) at the accept size class, compared to SS1 (79.6%). This study suggests that deck screen is suitable for small scale operation considered lower purchase and maintenance cost. Also, different combination of screen sieves improves screen performance in deck screen operation.

size distribution,biomass feedstock,screen machine

K 2-4 (Konzerthaus Freiburg)

IUFRO17-655 **The effect of screening and drying of forest residue chips on fuel quality and combustion behavior in small boilers (< 50 kW)**

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Abstract: Wood chip boilers < 100 kW require homogeneous and high quality biofuels. To ensure high fuel qualities, low quality fuels such as wood chips from forest residues may be processed by secondary measures, e. g. by screening and drying.
Six field studies on screening and drying of forest residue chips were conducted including two drum, two star and two jigger screens. Drying was done technically using a rolling-bed, a belt and a walking floor dryer or in drying containers. Drying was also performed naturally in large storage piles. Fuel samples were collected before, during and after processing and analyzed for moisture content, ash content, net calorific value, bulk density, particle size distribution and chemical fuel quality. Wood chip quality was related to ISO 17225-4 and the newly developed ENplus certification scheme for wood chips. Combustion trials (CO, NOX, particle emissions) were performed on two boilers (30 kW and 50 kW).
Most forest residue chips could not be classified according to ISO 17225-4 / ENplus before processing. Screening ensured the reduction of fines which then allowed for classification as P31S or P45S. Moreover, screening reduced the amount of green biomass (e. g. needles) and impurities (e. g. mineral soil) and, thus, reduced ash content and concentrations of chemical elements (e. g. N or K). Technical drying provided wood chips with moisture contents < 15 w-% while natural drying in storage piles for several month sometimes still showed values > 30 w-%. Secondary fuel processing ensured conformity with fuel property classes of ISO 17225-4 and ENplus. Moreover, gaseous and particle emissions were reduced in some cases when using wood chips with improved fuel quality.
In conclusion, secondary measures such as screening and drying improved fuel quality and could improve combustion behavior in small boilers. Thus, even low quality forest residue chips may become suitable for residential combustion systems.

screening, drying, certification, combustion

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K 2-4 (Konzerthaus Freiburg)

IUFRO17-1022 **Windrowing and fuel chip quality of some residual forest biomasses in North Sweden**

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Abstract: There's a great unutilized potential of residual biomasses in Fennoscandia such as logging residues (LR) and whole tree-parts (WT). LR and WT are often seasoned in windrows and knowledge, prior to comminution, of their moisture content (MC) and dry mass (DM) densities is useful for logistics planning and value estimations. The aim was to compare windrow properties and fuel chip quality of LR and WT delivered to the same energy plant (EP) by one supplier during one season. 76 windrows were surveyed and chipped, of which 25 were sampled to assess MC, ash content (AC) and particle size distribution (PSD). Mean MC was 45% and it didn't significantly differ between LR and WT, but MC varied substantially within and between sites. LR had higher AC than WT (2.4% vs. 1.5%) and two-fold higher proportions of fines and oversized fractions. Windrow orientation didn't affect MC, while full exposition to ambient conditions decreased MC by 7% (LR). Density of LR averaged 66 oven-dry (OD) kg per stacked cubic metre (m^3st) and 59 OD kg/m^3st for WT, allowing building models for DM content prediction. Holistic supply chain management is crucial to assure that residual forest biomasses are delivered at high quality and cost-efficiency.

bioenergy, small-diameter trees, logging residues

K 2-4 (Konzerthaus Freiburg)

IUFRO17-711 **Forest biomass harvesting productivity and cost analysis in Australia**

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Abstract: The presentation includes a summary of five research projects on different biomass harvesting systems in Australian plantations. The first trial assessed the productivity and cost of slash-bundling the harvesting residues in clear felled area using Pinox slash-bundler in Eucalypt plantation in Tasmania. Second project investigated the efficiency of a European mobile chipper to collect pine harvesting residues Green Triangle (Victoria) while in the third project a conventional forwarder was studied to recover the pine residues logs (called Fibre plus material) as an integrated biomass operation in Western Australia. The product quality and fuel consumption of the biomass harvesting systems have been also assessed within the trials. Whole tree biomass harvesting (including feller-buncher, grapple skidder and chipper) was another trial carried out in low-productivity Eucalypt stands in Western Australia to produce biomass chips for bioenergy purposes. The operating costs and environmental impacts (including remaining residues assessment to sustain soil quality in biomass recovery operations) of different technologies will be compared/discussed in the presentation. Finally the impact of storage the residues for natural drying to reduce moisture content and optimisation of forest residues biomass supply chain (using a tool called BIOPLAN developed by Acuna el al. 2012) will be presented within a simulated biomass supply chain case study.

Biomass, Productivity, Cost, Optimisation

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2864 **Improvements of the chip supply system to reduce supply costs**

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Abstract: The choice of system for chipping and transport of chips has changed during the last decades in Sweden. Forwarder mounted chippers combined with container trucks or self-loading chip trucks were the dominating chip supply systems in the early 21st century. The new chippertrucks were considered niche machines for small landings close to customer. Currently, chippertrucks produce around 50% of all chips produced at landings. It reduces relocation costs between sites, is easy to plan for, no machine interaction causes delays, and the production level is stable at about 2 loads per shift. Chipping work with a chippertruck cost more than for a dedicated chipper, due to lower utilisation of the chipper, and chip transports are cheaper if chip trucks are used as they load more. New systems are introduced to exploit these possibilities to decrease costs and to increase effective chipping time for dedicated chippers. This increases system production and flexibility compared to chippertrucks, but necessitates increased planning to avoid organisational delays. Truck mounted high capacity chippers, chipping directly into 64 or 74 tonnes GVW chip trucks is an interesting system. The chipper tow an extra chip trailer, which is filled in case of a lack of chip trucks.

Biomass, Energy, Chipping, Transport

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168 - Sustainable forest operations - A foundation of the green economy

KG I - 1098 (Uni Freiburg)

IUFRO17-829 **The "Sustainable Forest Operations" Concept: Past, Present, and Future**

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Abstract: The IUFRO Task Force on Climate Change and Forest Health has recently provided an opportunity for forest operations scientists around the globe to examine the concept and approaches of sustainable forest operations (SFO) in the light of new challenges facing forests and forestry in changing climate.
Intensified forest management is inevitable due to continuously increasing human population and their demand for wood products. While it is important to recognize the level of forest harvesting intensity, as well as social and environmental issues vary by region, climate change directly and indirectly affect forest management activities across the globe. Other global issues facing forestry include illegal logging, ergonomics (human factors), and quality improvement on both forest production and environment. These considerations should be included in the planning, implementation and assessment of forest operations to ensure its sustainability.
This presentation describes the evolution of the SFO concept from the past to the present based on their focus and scale. A new concept of SFO is then proposed for the future to consider new challenges, issues and changing demands on forests and forestry. The aim of the new SFO concept is to holistically address forest production, ecosystem services, environmental protection, and social values and wellness.

Forest operation, Sustinability, Environment

KG I - 1098 (Uni Freiburg)

IUFRO17-258 **Forest Operations and Sustainable Supply Chains**

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Abstract: The purpose of this presentation is to place the field of forest operations within sustainability debates. It discusses a sustainability understanding linked to forest operations supply chains in the United States. It integrates ecological, cost, social and market factors, as well as, the operator performance conditions surrounding the supply operations of forest products. By integrating the basics of sustainability understandings, supply chain analysis as well as the logistics linked to forest operations and management, a much needed broader and integrated perspective of forest products supply chains is sought.

forest operations, sustainabilty, considerations

KG I - 1098 (Uni Freiburg)

IUFRO17-422 **Ergonomics as A Pillar of Sustainable Forest Operation**

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Abstract: Forest operations consist of forest management plans (ea. funds allocation, work and workforce organizations, training), harvesting operations, and post harvesting operation (ea. forest protection, silviculture, forest community empowerment). The operations are closely associated with the high accident and health disturbance risk, triggered by human-made and nature-given sources of hazards that exposed the workers. Ergonomics (human factors), together with the environment, economics, quality, and society have been identified as essential elements of the operation. Ergonomics discusses capabilities, and at the same time, limitations of human (in this paper refers to forestry workers). Ergonomics seeks for optimum mutual adjustment between the workers and their work to achieve (a) good performance (ea. work productivity, quality of work) and (b) well-being of the workers (ea. safety, health, comfortability) in which the two are well considered as important keys to the success of sustainable forest operation. However, it is a miserable fact that most discussions on sustainable forest operations (especially in most developing countries) still put forestry worker's safety, health, comfortability, and productivity as minor objects that remain only in the form of manual and regulation, slogans, and other make-up ergonomics actions. It is obvious that serious and continuous efforts should be taken in macro, meso, and micro level of integrated- ergonomics actions. In the case of Indonesia, initiating a corrective action towards ergonomics-based instruments in mandatory Indonesian sustainable forest management certification scheme is recommended.

SFO, OSH, hazards, work productivity

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IUFRO17-574 **Environmental aspects of forest operation dedicated to industrial uses**

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Abstract: Life Cycle Assessment (LCA) is a standardized methodology to assess the environmental aspects and potential impacts associated with a product, process or activity from a life cycle perspective. This is an extended method with a holistic approach which guarantees the comprehensiveness of an environmental evaluation, assuring its reproducibility.
The forest sector has been at the vanguard in operationally applying the concept of sustainability along the years in order to introduce the indicators for sustainable forest management. The European forest sector is branded by a large diversity of forest types, socio-economic conditions and ownership structure.
Forest operations are considered as key activities in related forest based industries in terms of environmental and economic perspectives. In fact, the wood is the main renewable source used to produce both wooden products and energy. Thus, special attention must be paid on operations carried out at forest in order produce the raw material under a more environmental friendly system. Nowadays the interest on quantifying and analyzing the environmental impacts related to processes and products is constantly increasing. In this sense, forest sector is receiving special attention.
Therefore, the purpose of this LCA study is to determine, compare and discuss differences on the forest management scenarios for different species dedicated to industrial use, which lie on their environmental profiles.

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Forest sector; Environmental hotspots; Lca

KG I - 1098 (Uni Freiburg)

IUFRO17-3608 **Green logistics and multi-criteria optimization in biomass supply - methods and challenges: A review**

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Abstract: The optimization of biomass supply chains gained world-wide attention counting the published articles and studies. Delivery of biomass at low costs was in focus of supply chain optimization until recently, but there is now a strong interest to cope with environmental indicators as well for greener supply chains. Apparently the use of biomass affects the greenhouse gas balance in a positive way, because the production and procurement creates less emissions and replaces fossil fuel. However, there is still a number of unwanted environmental impacts during biomass supply like exhausts, noise, visual impact, road wear, soil and stand damage etc.

To cope with all this dimensions and sets of indicators, efficient multi-criteria decision making tools for supply chains should be used to support researchers and stakeholders in their decision making. Multi-criteria decision making methods is an emerging research field, with a huge variety of methods and tools. Another challenge in biomass supply but also generally in forestry is uncertainty, because of harsh weather conditions the access to resources could be limited. Furthermore, seasonal peaks in demand of customers, changing and sometimes unpredictable resource availability and quality hampers or delays efficient supply processes.

A comprehensive literature review of multi-criteria decision making for biomass supply chain optimization should give a brief introduction in successful applied approaches like weighting sum, e-constraint, stochastic optimization, AHP etc. The presentations of successful applications should help to identify appropriate tools for most common problems.

biomass, multi-criteria optimization, logistics

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IUFRO17-3318 **Development of forest biomass harvesting guidelines based on assessing changes in soil nutrient status**

de Vries, W.* (1); Spijker, J. (1); de Jong, A. (1)

(1) Wageningen University and Research, Wageningen, Netherlands

Abstract: The substitution of biomass for fossil fuels in energy consumption is a measure to decrease the emission of greenhouse gases and thereby mitigate global warming. Over recent years, this has led to an increasing interest to use tree harvest residues as feedstock for bioenergy. An important concern related to removal of harvesting residues is, however, the potential adverse effects on soil fertility caused by an increased nutrient removal, relative to conventional stem-only harvesting. In the Netherlands this is a major concern, because we have many forests on poor soils.
Here we report the development of forest harvesting guidelines for the Netherlands, distinguishing seven major tree species, seven soil types (various forms of sand, loam, clay and peat soils) and nine regions, with clear variations in atmospheric deposition of the nutrients of nitrogen (N), phosphorus (P), calcium (Ca), magnesium (Mg), potassium (K). The basis for the guidelines is a consistent modeling approach, assessing the change in soil nutrient status by comparison of nutrient inputs by deposition and weathering with nutrient outputs by harvesting and leaching for various timber harvesting scenarios, including both stem-only harvesting and additional removal of tree tops and branches. For each region-tree-soil combination we calculated the maximum amounts that can be harvested such that the output of the nutrients Ca, Mg, K and P is balanced with the inputs. Results showed that at current harvesting rates a negative balance is hardly calculated for the richer loamy to clayey soil types, while depletion can occur for the poorer sandy soils, particularly in Ca and K. We discuss the uncertainties when translating the results to an advisory system for timber harvesting.

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IUFRO17-2270 **Wet area maps for efficient planning and risk mitigation for mechanized logging operations on French mineral soils**

VUILLERMOZ, M.* (1); GINET, C. (2); CACOT, E. (3)

(1) FCBA, equipe approvisionnement, Champs sur Marne, France; (2) FCBA, Charrey sur Saone, France; (3) FCBA, Verneuil-sur-Vienne, France

Abstract: Forest work is heavily disturbed by high seasonal variation. Machine utilization is especially low when wet conditions make logging almost completely impossible on mineral soils prone to compaction. Superimposed are impacts of climate change that most likely will add to the complexity.

Over the years, many French companies developed their own risk mitigation strategies to secure their license to practice. Costly skid trails rehabilitations and low machine utilization rates, when teams need to travel from logging sites to avoid unpredicted trafficability-ban, are key indicators to monetize Environmental damages that forest-companies want to prevent.

Modern data management, information systems and inter-operability directives now make it possible to access, synthesize and eventually exploit data for different analysis as well as create tutorial and decision support.

A first prototype is being tested in North East France where soils conditions and seasonal variations create the most challenging situations for practitioners. A large range of geo-layers (soil, topography, weather, forest management...) are exploited with adapted water transfer models. Benefits from the wet area map is for now measured through comparative scenario planning with industrial logisticians and forest managers. Such feedback from targeted users also drives the dissemination strategy to secure that the tool and its theoretical framework can be adopted by a large number of forest companies, whether or not they work with integrated GIS - ERP.

trafficability, water map, risk mitigation

KG I - 1231 (Uni Freiburg)

IUFRO17-2762 **Harvester CAN-bus data for site trafficability mapping**

Ala-Ilomäki, J.* (1); Salmivaara, A. (1); Launiainen, S. (1); Lindeman, H. (2); Uusitalo, J. (2); Finér, L. (3)

(1) Natural Resources Institute Finland (Luke), Helsinki, Finland; (2) Natural Resources Institute Finland (Luke), Parkano, Finland; (3) Natural Resources Institute Finland (Luke), Joensuu, Finland

Abstract: Modern forest machines with hydrostatic transmission and CAN-bus engine and transmission management can be used to measure power expended in travelling. At constant speed on level ground the power is expended in overcoming motion resistance, which in turn is directly related to wheel sinkage and hence vehicle mobility or site trafficability. The harvester always precedes the forwarder on the site, making it feasible to use it to collect data on site trafficability to produce a mobility map for the forwarder. The process can be fully automated and comprehensive data collected at low cost.
CAN-bus trafficability mapping was tested with an 8-wheeled Ponsse Scorpion King harvester and 8-wheeled Ponsse Elk forwarder equipped for collecting transmission power expenditure in addition to appropriate standard CAN-bus information. Trafficability was also mapped based solely on diesel engine power in order to eliminate the need for an extra pressure transducer needed for transmission power monitoring.
CAN-bus data proved promising in mapping site trafficability when compared to soil penetration resistance and harvesting machinery wheel rut depth measurements on the test tracks. In big data scale, trafficability mapping can be based on diesel engine power measurement alone.

Trafficability, CAN-bus, soil strength, rut depth

KG I - 1231 (Uni Freiburg)

IUFRO17-534 **"Waterproof" harvesting with GIS in the Swedish forestry**

Friberg, G.* (1); Bergkvist, I. (1)

(1) The forestry research institute of Sweden, Uppsala, Sweden

Abstract: Using "depth to water index" (DTW) in forest harvesting operations and during harvest planning is potentially an effective tool for reduction of driving damages.

To quantify the potential of DTW this study comprise 36 harvesting sites spread over Sweden, in total 450 ha. Data on rut formations from 310 kilometers of machine trails and >10,000 were collected with GIS in the field.

Information about nature conservation, cultural heritages and other "no go areas" where terrain driving shall be avoided are commonly used at site level during harvesting operations in Sweden. In this study a DTW-map (depth to water index) was added to give further information about water and moist areas. In total, 0.06% of the machine trails had serious damage to soil and water and 80% of the severe rutting occurred in areas marked by the DTW as having a high groundwater level.

The result shows that the sites may be planned in different sections handled in specific ways to be both efficient and gentle to soil and water if using this DTW-map. However, the study suggests that just maps only, doesn't solve the problem of not being gentle to soil and water alone, adapted routines is key factors to succeed with this challenge.

The Swedish forestry has implementing DTW-maps since 2014 and the Swedish Forest Agency have provided DTW-map publicly on the web for the whole of Sweden. The employees operating the forest machines arguing this maps as helping decision support maps which make their every day work easier. They can use routines to make harvesting more gentle and efficient at the same time.

Providing the DTW-maps for forest planning enable the machine operators to avoid sensitive areas.

Harvesting, Rutting, Depth to water index,

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IUFRO17-2705 **Optimized Routing in Forestry with the Consideration of Multiple Economical and Ecological Objectives**

Hosseini, A.* (1); Lindroos, O. (2); Wadbro, E. (1)

(1) Umeå University, Umeå, Sweden; (2) Swedish University of Agricultural Sciences, Umeå, Sweden

Abstract: In forestry, roads are the backbone of efficient management. Poorly designed strip-road networks could result in costly operations and adverse environmental impact.
Hence, an optimized strip-road network is essential for reducing ecological impacts from driving (e.g., soil damage, CO2 emission), operational costs, and improving the forest management.
To this aim, defining proper economical and ecological objectives and how to formulate and combine them mathematically are crucial steps toward designing an ideal road network.

Forest strip-roads are used mainly for thinning but also for final harvesting.
Strip-road network design is a complex locational problem that involves how machines (harvester and forwarder) operate, terrain features (e.g., elevation, soil types), and ecological and environmental concerns (e.g., soil disturbance, water damage).
This work aims at finding the location of roads from which all trees can be reached by the harvester and forwarder in a time- and cost-effective way with minimum adverse environmental impact.
To this aim, it elucidates the key economical and ecological objectives involved in network design subject to simultaneously satisfying several conflicting operational and environmental goals.
The impact of the objectives on design of an optimal network is analyzed, and it is shown how to formulate and combine them mathematically.

Optimization, Forestry, Strip Road

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IUFRO17-3409 **Soil strength in relation to moisture content in fine-grained mineral forest soils in southern Finland**

Uusitalo, J.* (1); Lindeman, H. (1); Ala-Ilomäki, J. (2)

(1) Luke, Tampere, Finland; (2) Luke, Helsinki, Finland

Abstract: Soil moisture content is known to have significant effect on soil strength, especially in fine-grained mineral soils. This being the case, trafficability of forest soils usually comprise large seasonal variation. The aim of the paper is to demonstrate and quantify the importance of soil moisture content in regard to most important soil strength characteristics in typical fine-grained mineral soils in southern Finland.
Field studies were conducted on three separate test sites that each comprises 8 sample plots. Measurements of moisture content and soil strength were repeated 8 times during time frame of 1 and half years. Moisture content was measured with an electric TDR moisture probe. The measured strength characteristics include Cone index, shear strength and modulus of elasticity measured with a portable falling weight deflectometer. The models to be developed help practitioners and researcher to comprehend the magnitude of seasonal variation on the strength of forests soils.

forest trafficability, bearing capacity

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IUFRO17-1257 **Influence of soil compaction on Quercus robur seedlings establishment**

Mariotti, B.* (1); Cambi, M. (1); Maltoni, A. (1); Hoshika, Y. (2); Tani, A. (1); Marchi, E. (1)

(1) Università di Firenze , Firenze, Italy; (2) Consiglio Nazionale delle Ricerche (IPSP-CNR), Sesto Fiorentino, Italy

Abstract: Compaction of forest soil due to the increasing use of heavy machinery in forest management can affect seedling survival and establishment. Our study was aimed at assessing the effect of forest operations on soil physical parameters as well as on growth and physiology of Quercus robur seedlings during the first growing season since germination. The study was based on two experiments: one in field, where compaction was simulated by tractor passes, and one in nursery, where compaction was obtained by direct compression of the soil surface on the top of containers using a compression machine in laboratory. In the first experiment two levels of soil compaction were simulated (i.e. 10 vs. 25 tractor passes) and physiological and morphological attributes of the seedlings were measured during and at the end of the first year in field. The higher compaction level has affected the shoot system biomass, the number of growth flushes and leaves, the shoot/root ratio and the main root length. These aspects were accompanied by lower photosynthetic rate and leaf nitrogen content. In the second experiment we investigated the effect on soil compaction on above and below ground morphological traits of seedlings grown in plastic containers during the first month after germination. Three compaction levels were considered. The results showed significant differences between the compaction treatments and highlighted a constraint effect of increasing levels of compaction on root system development during the first growth stages after germination. Especially in Mediterranean forests, as the photosynthetic rate differed greatly between the compaction treatments in late summer, the shorter main-roots developed due to the soil compaction may limit the availability of water and nutrients to seedlings for more favorable climatic conditions after the summer drought.

regeneration, forest operations

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IUFRO17-1275 **Benchmarking of Cost Rates in Forest Harvesting Operations in Different Global Regions**

Di Fulvio, F.* (1); Lindroos, O. (2)

(1) IIASA, ESM, Laxenburg, Austria; (2) SLU, UMEÅ, Sweden

Abstract: In a global bioeconomy, benchmarking of costs is an essential practice in the evaluation of production systems and addressing decisions on the most efficient supply from available resources. In the case of forestry, benchmarking of cost rates for forest harvesting operations is extremely challenging, due to a lack of harmonized terminology and difficulties in collecting information on comparable supply systems. For these reasons, we initiated a global collection of forest harvesting cost rates which involved 19 experts from 15 countries spread in the five different continents. The data were compiled by use of a standardized survey to experts. This benchmarking identifies and updates the knowledge on technical and especially socio-economic factors capable of influencing the cost rates. This benchmarking provides a first time series of fully comparable cost factors to be used when modeling and evaluating the cost competitiveness of forest harvesting operations on a global scale. This example is expected to be extended in larger investigations, and regularly updated, in order to identify emerging technical and economic trends and to provide up to date cost rates that can be used by forest practitioners and decision makers for improving their cost efficiency and for designing future forest supply systems.

cost rate database, operational competitiveness

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IUFRO17-1732 **Life Cycle Analysis of thermal use of woodchips from conifer thinnings considering delivered heat (MWht) as functional unit: A case-study from a logistic terminal close to Madrid (Spain).**

Tolosana, E.* (1); Laina, R. (1); Martín-SanRomán, Á. (1)

(1) ETSI Montes, Forestal y del Medio Natural, Technical University of Madrid (UPM), Madrid, Spain

Abstract: A LCA of the use of forest biomass (pulpwood from pine plantation thinnings chipped at a logistic terminal in Lozoyuela, Madrid) to produce thermal energy has been performed. The whole cycle has been studied, from the logging operations to the final distribution and consumption of heat at one of the main final user's facility (a campsite with heated swimming pools). The fabrication, transport and final disposal of capital goods used during the processes have been also considered. The ReCiPe 2008 LCA methodology has been applied, using the SimaPro software. The considered impact categories were climatic change, ozone depletion, terrestrial acidification, fresh water and marine eutrophication, human toxicity, photochemical oxidants, particulate matter, terrestrial, fresh water and marine ecotoxicity, ionizing radiation and natural land transformation. The chosen functional unit was the thermal MWh available to final users. The most relevant impacts come from the use of electricity - taken from the Spanish net - to feed the chips to the boiler and to distribute the heated water. Because of that, the alternative of using only photovoltaic electricity was studied, and the majority of the negative impacts were significantly reduced. Also the LCA of the present heat production with woodchips was compared to the alternative of using a similar performance diesel oil boiler. The latter would increase strongly the majority of the negative impacts.

renewable,biomass,mechanization,LCA,capital goods

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IUFRO17-3246 **Photogrammetry estimation of wheel ruts dimension and soil compaction caused by a forwarder.**

Marra, E.* (1); Cambi, M. (1); Fernandez Lacruz, R. (2); Giannetti, F. (1); Marchi, E. (1); Nordfjell, T. (2)

(1) University of Florence - GESAAF, Florence, Italy; (2) Swedish University of Agricultural Sciences, Umea, Sweden

Abstract: Soil compaction and rutting are consequences of forest logging and is usually investigated by means of time-consuming methods, not able to represent the whole longitudinal profiles of forest trails. New methods based on photogrammetry have been developed. The overall objective of this study was to compare photogrammetry and traditional methods (cone penetrometer, manual rut depth measurements, soil bulk density and porosity) for evaluating rutting (depth and rut volume) and its relation with traditional measurements after repetitive passes of a loaded forwarder and two different levels of tire pressure. The comparison of photogrammetric vs manually-measured profiles resulted in R^2 of 0.934. The results showed the effect of tire inflation pressure and number of passes on soil disturbance. The estimation of the rut volume caused by the forwarder on 100 m long trails after 60 passes were 8.48 m^3 and 5.74 m^3 for tire pressure of 300 kPa and 150 kPa, respectively. The results showed a relation between soil compaction, rut volume and soil porosity. Increased rut volume correlated positively with increased soil compaction and decreased soil porosity. Structure For Motion photogrammetry can be an accurate instrument for high-resolution Digital Evolution Model creation and for morphology description of forest soil disturbance after forest logging.

SFM; DEM; forest operations; rutting; tracks.

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Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2916 **Impact of Light and Moisture on the Survival and Development of Planted Pacific Northwest Timber Species**

Aghai, M.* (1); Ettl, G. (2)

(1) University of Washington, Paloma Institute, Seattle, United States; (2) University of Washington, Center for Sustainable Forestry, Seattle, United States

Abstract: Intensive management of the conifer-dominated forests of Washington and the greater Pacific Northwest (PNW) has resulted in millions of acres of largely mono-specific forests, with simple vertical structure and low biodiversity. Improving the structural diversity of forest stands in the PNW is important for timber species diversity and as a means of improving ecological resilience in these managed ecosystems. Our research addresses the establishment potential of underplanted seedlings in partial light and in varying seasonal moisture conditions through comprehensive parallel field and greenhouse trials. Understanding species-specific ecophysiology and development trends is a first step in producing multi-cohort stands following non-clearcut harvesting practices.

The study incorporated Abies grandis, Acer macrophylum, Alnus rubra, Larix occidentalis, Pinus monticola, Pinus ponderosa, Pseudotsuga menziesii, Thuja plicata, and Tsuga heterophylla; for which intraspecific seed provenance and nursery culture were coordinated to improve regional relevance and reduce confounding effects. In addition to classic mensuration techniques, to confirm the targeted percent available light levels in situ, hemispherical photography and ceptometer measurements were employed. Research plots were located throughout the Puget Trough Ecoregion and the Eastern Cascade Foothills Region in Washington State, USA. Preliminary findings suggest first year mortality is driven by stock quality for hardwoods and pines. Rhizosphere moisture is a more significant driver of first year survival and growth than percent available light. The presentation will highlight seedling survival, morphology (growth and development), aboveground physiology (e.g. chlorophyll fluorescence [Fv/Fm]), as well as susceptibility to herbivory and disease following two years of experimentation. Mechanisms driving early survival and growth and practical implications of research findings will also be presented.

regeneration, ecological forestry, ecophysiology

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-788 **Cultivation of containerized forest planting material in Sweden - state-of-the-art and future technology**

Mattsson, A.* (1)

(1) Dalarna University, Energy Forests and Built Environments, Falun, Sweden

Abstract: In 2016, Swedish forest nurseries produced almost 400 million seedlings of which about 85% were containerized. This presentation aims to give a general description of the state-of-the-art method and present a new technology for year-around production based on the research cooperation between Dalarna University and leading forest companies in Sweden.

The state-of-the art is bounded to the vegetation period which limits the production time normally from May to September. The production starts with sowing, germination and early growth in conventional plastic greenhouses. The seedlings are irrigated and fertilized automatically, and when needed, the greenhouses are heated and illuminated. After early growth in the greenhouse the seedlings are moved to an outdoor area for completion of growth and hardening off. Finally, they are stored during winter in a cold storage or on outdoors under snow coverage.

The future technology is based on year-around cultivation in a closed plant growth chamber not affected by the outdoor climate. The illumination is provided by LED lamps and the temperature, humidity and water content in the growing substrate are automatically controlled. In the growth chamber the seedlings are pre-cultivated in a multi-layer arrangement at a high growing density to optimize the space used. After pre-cultivation the seedlings are automatically transplanted to any optional container system and moved to an outdoor area for completion of growth.

The advantages of this technology include: year-around production, equal volumes to state-of-the-art in much less space, reduced energy consumption and better cost efficiency. Also the new concept involves environmental benefits such as less water consumption, minimal use of pesticides, reduced nutrient leakage and lower CO_2 emissions.

Forest nurseries; cultivation; growth chamber

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2855 **Possibilities in using different light qualities in modifying growth and morphology of Scots pine seedlings under nursery conditions**

Riikonen, J.* (1)

(1) Natural Resources Institute Finland , Suonenjoki, Finland

Abstract: As a shade-intolerant species, Scots pine (*Pinus sylvestris*) strongly responds to alterations in light quality. Although the importance of light quality in determining growth and development of plants in well known, the development of applications for improving seedling quality and production efficiency in nurseries has only been started recently. Several experiments studying the effects of different proportions on blue (400-500 nm), red (600-700 nm), and far-red radiation (FR, 700-800 nm) on growth, morphology, and subsequent field performance of Scots pine seedlings have been conducted in Finland. Light-emitting diodes (LEDs) were used either as sole sources of radiation or as supplemental light sources in addition to sun light. The light treatments were applied either during whole growing season or during a pre-cultivation period of few weeks. In this presentation, the results of these experiments will be summarized. It was found that by manipulating FR content in growth light it was possible to control growth habit (secondary vs. primary needle seedlings), growth rate and growth cessation of the seedlings, which enables production of seedlings targeted for outplanting on sites with specific characteristics. For example, some characteristics related to drought tolerance can be enhanced by omitting FR light from the growth light. Blue light reduced height growth, indicating that blue light could be used as a growth retardant at the nurseries, although determination of proper dose of blue light requires further studies. Growth and morphology of the pre-cultivated seedlings were also modified by different light spectral composition, but these changes disappeared soon after transplanting and transition of the seedlings to sun light. Increasing knowledge of the potential effects of different wavelength combinations on seedling growth and morphology will enable development of new applications to be used in commercial seedling production in the future.

nursery, Pinus sylvestris, spectral composition

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Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-4169 **The Effects of Varying Light and Rhizosphere Moisture on Early Growth and Development of Pacific Northwest Timber Species**

Moskowitz, O.* (1); Aghai, M. M. (1); Ettl, G. (1)

(1) University of Washington, Seattle, United States

Abstract: Variable retention, partial cutting, or gap-based systems are increasingly being employed in the Pacific Northwest region as "alternative silviculture" or "ecological forestry" approaches to changing Douglas-fir plantation trajectories. Following these non-clearcut harvests, the resulting gaps in the canopies vary in size and distribution of the overstory, thereby causing often drastic differences in both the amount and quality of light and rhizosphere moisture available to seedlings. This experiment is an ex situ potted simulation of field conditions used to 1) to determine the specific thresholds of post- transplant survival and development in response to a precise range of light and moisture regimes and 2) help calibrate a parallel field trial with the same stock and species assortments.
Forestry stock of 12 species of native trees of the region (N per species= 90) were planted into large pots, then shade cloth and plastic poly were used to control light and moisture conditions. This experiment followed a factorial design including three light treatments and three moisture regimes with replication. Seedling responses were assessed by repeated measurements of survival and morphology for growth response. Destructive sampling entailing assessments of dry mass, and carbon and nitrogen distribution for roots, shoots, and foliage was employed prior to transplant into the experiment and following one year of growth. Overall, there were important interactions between light and water availability on seedling performance. Most species acquired the greatest biomass under open light and wetter than normal conditions. Light, more so than rhizosphere moisture, was the significant driver of nearly every morphological response measured. The presentation will highlight species-specific results and findings relevant to reforestation practitioners.

reforestation, alternative silviculture, seedlings

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3881 **The economic and social consequences of introduced tree species silviculture - in the case of Douglas fir, red oak and black locust in Central Europe**

Gruchala, A.* (1); Zasada, M. (1); Bronisz, K. (1)

(1) Warsaw University of Life Sciences, Faculty of Forestry, Warsaw, Poland

Abstract: Introducing alien tree species to forest management has caused various objections in many Central European countries. The foundations of these objections vary, but usually they show a lack of comprehensive, large-scale, long-term study, that illustrate the potential ecological consequences of the introduction of these species. This stands in contrast, however, to research on the environmental impact of forest stands composed of alien species led over the years in countries such as, Germany, the Czech Republic and Poland. The potential negative impact has been proven for some species, but the potential productivity and adaptation to changing climate conditions has also been emphasized.
In this paper we present results about the silviculture of introduced alien species such as Douglas fir, red oak and black locust. We define the productivity and economic potential of stands consisting of these species compared to local ones growing in similar site conditions. Based on the economic analysis we present the differences in costs, productivity and the value of stands under different management regimes. We also discuss the social aspects of such management, especially in the context of rural development. The society of large cities and its attitude towards controlling game populations in municipal forests.

Alien species, economic efficiency, productivity

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1333 **Direct Seeding in Reforestation - A Field Performance Review**

Ivetic, V.* (1); Grossnickle, S. (2)

(1) University of Belgrade - Faculty of Forestry, Belgrade, Serbia; (2) NurseryToForest Solutions, Sidney, BC, Canada

Abstract: The use of seeding with tree species has been an ongoing silvicultural practice in forest restoration programs for centuries. Declining of direct seeding practice started in 1950s, with improvements of nursery production of quality planting material. In recent years it has been increasingly recommended for use in restoration of abandoned agricultural sites, disturbed forests, opencast mine reclamation sites, reintroduction of endangered tree species, reforestation, and afforestation. This review examines the field performance of direct seeding in forest restoration programs from a number of perspectives. First, merits of using direct seeding in restoration programs are defined. Second, the reasons for the decline in direct seeding in restoration programs. Third, the current best practices and potential new practices to apply direct seeding in restoration programs are reviewed. The intent of this review is to provide a synthesis of what is known about direct seeding, thereby allowing practitioners to make a rational decision of whether to apply this practice towards their forest restoration program. This review represents a comprehensive, though not exhaustive, examination of published literature on the subject of direct seeding. However, this review was comprehensive enough to describe the major trends found in recently published work.

direct seeding, reforestation, field performance

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Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3918 **Importance of Developing and Supporting Quality Nursery Facilities and Staff to Meet Reforestation Needs**

Haase, D.* (1)

(1) USDA Forest Service, Portland, United States

Abstract: Using high-quality plants of specific species from genetically appropriate sources is a key component for meeting reforestation and restoration goals. Nurseries are one of the most effective and efficient means for obtaining the necessary plants. The nursery's critical role, however, is often overlooked and neglected. Many nurseries lack adequate resources and expertise necessary to produce plants that will survive and thrive after outplanting. Poor-quality plants can result in insufficient or delayed target stocking levels, establishment and spread of competing vegetation, a need for re-planting, and failure to meet project goals. In spite of these environmental and economic costs, investments into nursery technology, infrastructure, and personnel are frequently a low priority throughout the world. Nurseries require the proper tools, supplies, and facilities, along with skilled, knowledgeable staff, to produce adequate numbers of plants with high-quality morphological, physiological, and genetic characteristics for meeting long-term forest health goals under a variety of ecological conditions. This presentation will address: 1) wide-reaching problems caused by insufficient nursery support, 2) priority nursery needs that must be supported, 3) strategies for providing support, and 4) the widespread benefits of high-quality plants and their subsequent field performance. Several examples will be provided to illustrate these points.

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2142 **Scots pine (Pinus sylvestris L.) growth response to variable environmental conditions in Poland**

Kowalczyk, J.* (1); Chmura, D. J. (2); Barzdajn, W. (3); Buraczyk, W. (4); Rzonca, M. (1); Guziejko, A. (1); Matras, J. (1); Rozkowski, R. (2); Skrzyszewska, K. (5)

(1) Forest Research Institute, IBL, Sekocin Stary, Poland; (2) Intsitute of Dendrology, Polish Academy of Sciences, Kórnik, Poland; (3) University of Life Sciences, Faculty of Forestry, Poznan, Poland; (4) Warsaw University of Life Science, Department of Silviculture, Warszawa, Poland; (5) University of Agriculture in Kraków, Faculty of Forestry, Kraków, Poland

Abstract: In order to continue wood production at a similar level as at present, forest management practices require preparation for climate change. An important aspect of these measures is a better use of genetic potential and intra-species variability of forest tree species.
We studied variation among provenances of Scots pine in tree diameter measured at the common-garden sites established within the 1967 and IUFRO 1982 experimental series in Poland. At each studied site we calculated basal area per hectare (BA) for provenance, and data were standardized. The summarized results showed a clear variation in growth and a potential for adaptation to changing climate. Populations from central Europe were growing faster compared to those from the southern and northern ranges of the natural distribution in Europe. Local populations were not always among the best-performing at their home location. Breed populations established by humans (e.g. at Porn óapáti, Hungary, and Ardennes, Belgium) grew better comparing with natural populations. The analyses utilized the set of data available from the software generating climate data for Europe (ClimateEU v4.63). Regression models showed that growth generally decreased from west to east when a population was transferred from its place of origin to a distinctly different location. Strong relationships were found between BA and transfer distances measured as a difference in degree-days above 5 °C of provenance origin and planting sites. Results indicate that the appropriate use of forest reproductive material (FRM) is one of the possible ways to adapt forests to unfavourable changes in climate.

management; climate change; breeding; Scots pine

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1043 **Prospects for restoration of degraded landscapes within the Yavoriv sulphur quarry (Ukraine) through woodland development.**

Kopiy, S.* (1); Nijnik, M. (2); Nijnik, A. (3); Kopiy, M. (1)

(1) Ukrainian national forestry university, Lviv, Ukraine; (2) The James Hutton Institute, Aberdeen, United Kingdom; (3) Environmental Network Limited, , Aberdeen, United Kingdom

Abstract: Abstract
This paper considers prospects for restoration of degraded landscapes within the Yavoriv sulphur quarry, Western part of Ukraine, where the mines are now largely abandoned; and the devastated land is undergoing agricultural, forest and meadow reclamation or is left for natural processes of self-recovery. We conducted an interdisciplinary study to examine the state of environment, specify species biodiversity, and develop understanding of prospects for ecosystems' rehabilitation through woodland development. The research methods included: i) desk-based review of the literature and policy documents; ii) pilot field-based soils science survey of biological activity of technogenic soils and its biodiversity; iii) ecological science field-based analysis of the vegetation and species composition, plant associations and ecosystem variation; iv) natural science field-based investigation of self-restoration processes on the devastated land to find out the most appropriate for these conditions species; v) participatory methods to identify the attitudes of local people towards landscape restoration measures and future use of the land. Results confirm the hypothesis that open excavation of sulphur has led to soil destruction and erosion; water, air and soil pollution; deterioration of landscapes, and the decrease of biological diversity. Innovative knowledge concerning the influence of species biodiversity of the vegetation on the effectiveness of land recovery has been developed. A better understanding of the role of phyto-ameliorative measures (e.g. of biological re-cultivation via woodlands establishment) in boosting species biodiversity and in the subsequent delivery of a range of ecosystem services from a formerly devastated land has been achieved. Findings from a social science component of this study indicate that future use of the restored land will likely be outdoor recreation.

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121 - Reforestation challenges: planting material, ecophysiology, biodiversity, climate change mitigation

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1274 **Control of forest reproductive material in the Single European Market**

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Abstract: Forest reproductive material (FRM) of unsuitable provenance leaves the forest owner with high risks and low revenues. Today FRM is transferred across Europe in significant amounts. The existing legal regulations on FRM moved in trade can, however, only provide for an absolute proof of identity at an unproportionally intense level of controlling. The presentation will provide insights into the legal and policy frameworks for the production, marketing and control of FRM in Europe including recent developments and activities for harmonisation with the world-wide applied voluntary OECD Scheme. It will focus on similarities and differences in the implementation of the European Directive 105/199 in different EU Member States. Conclusions arising from it will be discussed, between them the demand for harmonized and more stringent control of FRM at all production and marketing stages and close cooperation between control agencies in different EU-member states.

The rapid development in the field of genetic investigations on forest tree species during the last two decades opened new control possibilities. New traceability systems using genetic methods have been developed in recent years and put into practice in a few countries generally applying private rules. Posibilities and limits for the application of genetic markers for proof of identity within private based certification systems will be presented for some species. The supplementary control systems do not replace the legal regulations but enforce their applications. Thus they secure a significant contribution to stability and yield of our forests.

FRM, control, legal regulations, certification

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1045 **Reforestation challenges on fine-textured soils in boreal forest**

Saksa, T.* (1); Heiskanen, J. (1)

(1) Natural Resources Institute Finland, Suonenjoki, Finland

Abstract: Mounding is a common soil preparation practice with planting Norway spruce seedlings (Picea abies (L.) Karst.) in Finland. On fine-grained soils, however, the postplanting performance of seedlings with mounding has been poorer than on coarser soils.

Effects of different soil preparation treatments on the postplanting performance of Norway spruce container seedlings were examined in two studies. The first study was carried out on till soils susceptible to frost heave and the second on soils ranging from medium-grained tills to sorted clay. In both studies the postplanting performance was measured for three growing seasons.

The results showed that mounding decreased expectedly seedling mortality and increased growth on all studied soil textures. The mounding method or mound height showed no clear difference in seedling growth. Frost heave was present mainly on ditch mounded and inverted spots. The results suggest that ditch or spot mounding should be used on fine-grained soils. Seedling growth and survival were slightly negatively related to the soil clay content; the seedling attributes tended to be poorest on silty soils with a clay content of 20-30% (or silt and fine sand content of over 60%). The results suggest that effective soil preparation cannot fully alleviate all of the inherent disadvantageous effects of silty soils.

Picea abies, mounding, planting, soil texture

All Division 3 (Forest Operations Engineering and Management) Meeting

10 - Innovations in forest operations for better serving evolving societal needs

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1755 **French research and innovative plan by 2025 for wood-based industry: focus on precision forestry**

CACOT, E.* (1); VUILLERMOZ, M. (2)

(1) FCBA, Verneuil-sur-Vienne, France; (2) FCBA, Champs-sur-Marne, France

Abstract: In 2016, the French 2025 research and innovation plan (FBRI 2025) was defined on national level. Regarding forest operations, 2 main challenges are taken into account: willingness to increase harvest with +12 million cubic meters, need to counteract the constant decrease of manual workforce (-400 lumberjacks/year).

Promoting the intelligent monitoring and management of forest through the development of remote sensing technologies to better characterize resources and potential harvest is one of the 13 strategic projects.

The development of technological (mechanization, automation...) and organizational solutions for precision forestry is another backbone of FBRI 2025, as a direct confirmation of graduate changes of practice adopted in the past decades.

Digital transition adds-up to improve mobilization and logistics in the forest-based sector, thus improving efficiency by automated access to data (resources, access roads), improved reliability of data exchanges and traceability of timber using collaborative digital systems.

Whether they are progressive or ground-breaking, those target innovations are linked to human factors. Change management is therefore interwoven with all technological developments. And on the mid-term a national consultation is also required on how to modernize and redesign training and education in the forest-based sector. Improving the alignment of training opportunities with the required skills, modernizing vocational training, adapting training programs and keeping up with changes of practice in the sector are suggested but will require as much collaborative effort as cutting-edge research to become the demanded reality.

Undertaken actions will be illustrated by some on-going or future projects, in order to highlight their technical, organizational and human challenges.

Forest operations, innovation, precision forestry

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1648 **New Market of Contractor Firms in the Slovak Forestry Service Sector and Innovation Policy**

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(1) Technical University in Zvolen , Zvolen, Slovakia

Abstract: The aim of the presentation is to evaluate innovation behaviour and potential of contractor firms, as well as the transformation and the functioning of innovation policy, in the Slovak forestry service sector. Firstly, the presentation deals with the issue of innovation theory, theory of innovation systems, it also describes innovation policy in forestry and characterizes a new market of forestry services in Slovakia. Methodologically, the combination of scientific methods and approaches was used. A questionnaire survey was used for the evaluation of innovation behaviour of contractor firms in the forestry service sector. In response to a questionnaire survey, for the evaluation of innovation potential of firms, the method of collective case study with 13 cases was used. The evaluation of innovation policy was focused on the analysis of the fulfilment of three basic functions of the sectorial innovation system: (i) reduction of uncertainties by providing information, (ii) management of conflicts and cooperation, and (iii) the provision of pecuniary and non-pecuniary incentives. Lastly, inductive and deductive reasoning was used to make recommendations for innovation policy in the sector. The results pointed out, that innovation activity of firms is low, while their innovation potential is high. Innovation activities were oriented on the procurement of a new technology, because the current mechanisation does not meet the needs for the development of modern technology. At the same time, innovation system in the sector fulfils its three basic functions at insufficient level. The cooperation and interactions between the various actors are weak and the innovation system does not provide enough information for the reduction of uncertainties. The last part of the presentation makes recommendations for innovation policy in forestry. The importance and benefits of these measures is in creating conditions for improving innovation and entrepreneurial activity in the sector.

innovation, behaviour, potential, policy, Slovakia

All Division 3 (Forest Operations Engineering and Management) Meeting

10 - Innovations in forest operations for better serving evolving societal needs

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-2156 **Pre-harvest tree and stand assessment for improved log allocation within the wood supply chain**

Opferkuch, M.* (1); Smaltschinski, T. (1); Jaeger, D. (1); Becker, G. (2)

(1) Chair of Forest Operations, University of Freiburg, Freiburg, Germany; (2) Chair of Forest Utilization, University of Freiburg, Freiburg, Germany

Abstract: Moving the process of identifying the right raw material for specific products upstream to earlier stages in the wood supply chain has long been described as key element for efficiency increase. Realization of such a pre-harvest log allocation requires information on quantity and quality of the trees to be harvested. Forest inventories typically do not fulfil this requirement. The problem is of larger importance in selective-cutting regimes as it needs to be known which trees will be cut.
The combination of airborne and terrestrial LiDAR (ALS, TLS) data can provide consistent information on the growing stock and allows the calculation of utilization volume and possible assortments. Tree height (h) and crown parameters from ALS data and the diameter at breast height (dbh) from TLS on sample plot level allows estimating dbh by linear regression with ALS crown parameters as independent variables. This regression can then be used for upscaling to the enterprise level for which ALS-crown and tree height data are available. The stem diameter at 7 m height (d7) can also be estimated by linear regression with dbh as independent variable. With these three variables (dbh, d7, h) single-tree volumes can be estimated accurately for Central Europe with the software BDATpro. Each tree's relation to a stand is given by its coordinates, which in turn allows modeling stand-specific volume distributions. Including the Weibull function and the modification of its parameters allows modeling utilization covering the full range from 'thinnings from below' to 'thinnings from above'. The utilization rates can then be modeled for each stand in the same way and the assortments can be calculated by bucking simulation. Quality information is derived from TLS data (taper, sweep).
This pre-harvest information for the whole forest enterprise is the necessary pre-requisite towards the idea of a forest warehouse with the required flexibility regarding the log products to be produced.

forest warehouse, pre-harvest quality assessment

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-898 **Using a prototype load test platform to quantify the effects of steel flexible tracks on forwarder peak load distribution**

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(1) Technische Universität München, Forest Operations, Freising, Germany; (2) Albert-Ludwigs-Universität Freiburg, Chair of Forest Operations, Freiburg, Germany

Abstract: With increasing payloads, machines used in mechanized forest operations to transport wood from felling sites to landing areas along machine operating trails can cause severe soil disturbances through an increase in soil density. The densification of a forest soil needs to be avoided as it reduces and potentially eliminates macropores, which are essential for plant growth. In an attempt to increase machine traction and extend trafficability in areas with high soil moisture, steel flexible tracks (SFT) are regularly installed on bogie axles of forwarders. These SFT span the entire length of a bogie axle and form an oval geometry, thereby increasing the area of contact between the machine and the operating surface. The study quantified dynamic peak loads exerted by a forwarder driving either on wheels or using additional SFT on its rear bogie axle. To examine load distribution of a full-scale forwarder, a load test platform equipped with 24 high capacity load cells placed below a matrix of steel plates was designed and constructed. Three scenarios were tested with the forwarder unloaded and loaded to quantify the difference in peak loads between wheels driven directly over the steel load test platform (considered as rigid surface, scenario 1) and SFT when either driven directly over the steel load test platform (scenario 2) or when driven over a 20 cm layer of sand placed over the platform (considered as flexible surface, scenario 3). The prototype platform proved to be an appropriate measuring device for full-scale tests. Results indicate that when operated on the sand layer, SFT (installed on the forwarder's rear unloaded axle) decreased dynamic peak loads by about 30% compared to wheels operated on the sand covered platform. The use of SFT on bogie axles of forest machines is recommended to lower soil disturbances, especially through a reduction of peak loads often responsible for negatively altering soil physical properties.

dynamic loads, off-road traffic, bogie-axles

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-4052 **Modelling changes in surface flow after skid trail construction in steep terrain**

Talbot, B.* (1); Pierzchala, M. (1); Astrup, R. (1)

(1) Norwegian Institute for Bioeconomy Research, Aas, Norway

Abstract: This paper presents the methods developed and results of a case study in which the changes to hydrological surface flow on a steep hill slope are modelled after a network of skid trails were constructed in connection with clearcut harvesting.

ALS data was used in constructing a terrain model for the site before harvesting, while images acquired from a UAV were used in generating a surface model, which included the skid trail network and thereby represented the post-harvest condition of the site. Three years of local climate data peaks (rainfall magnitude and intensity) were used in modelling hydrological flow after the terrain surface was altered. Changes in flow accumulation and the probability of erosion 'hotspots' were analysed in a QGIS environment. The site was revisited 3 years after harvesting and evaluated against the predicted impact of the changed surface flow patterns.

Steep terrain, hydrology, erosion, logging

All Division 3 (Forest Operations Engineering and Management) Meeting

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KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1753 **Multifunctional biomass terminals in a bioeconomy**

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Abstract: In a bioeconomy, a vast number of biomaterial qualities shall be produced, harvested, sorted, handled, pre-processed and delivered to biorefineries. Such market calls for new logistic solutions and business models. Conventional terminals can be classified as satellite terminals, feed-in terminals and transshipment terminals which together serve as intermediate storage, upgrading and transfer points. In a bioeconomy forest biomass terminals are expected to be more sophisticated in their function. For example, beside fulfilling the criteria of conventional terminals they will also serve as sorting, fractioning, pre-refining and refining stations Thus, a development towards a whole-tree utilization supply chains seem likely were biomaterials from the tree are customer-oriented in order to optimize the raw material utilization and maximize profit. Using current knowledge of expected biomass demands, possible terminal design combined with new technological inventions for e.g. fractioning of biomass, pre-treatments and supply management tools would boost the development and the transition. In order to optimize forest products the multifunctional terminals will require proper design of e.g. infrastructure, operations and management. The Infrastructure, operations and management must then match in order to minimize terminal cost. The management tools must render effective track-keeping of e.g. qualities, quantities, operation performance and biomass- and information flows.

bioenergy, business models, logistics

All Division 3 (Forest Operations Engineering and Management) Meeting

114 - Transforming low grade logs and residues into higher value products through improved supply chain

KG I - 1139 (Uni Freiburg)

IUFRO17-1107 **Fuel consumption and GHG emissions of forest biomass supply chains in Northern Sweden: a comparison analysis between integrated and conventional supply chains**

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(1) SLU, Umeå, Sweden; (2) University of Santiago de Compostela, Santiago de Compostela, Spain

Abstract: Forest biomass can be used as source of renewable energy, contributing to mitigate climate change. Currently, forest biomass is one of the most important energy sources in Sweden, accounting for around 20% of the total supply. New demands of forest biomass may be expected due to the EU energy targets, the previous high oil prices, the energy supply security, and the bioenergy market. However, the supply depends on the intensity of conventional final felling operations. Thus, it is crucial to determine the energy demands of conventional and new forest assortment supply chains and promote those with the highest energy efficiency and least greenhouse gas (GHG) emissions.

An attributional Life Cycle Assessment approach was used to evaluate the fuel consumption and GHG emissions associated with the combustion of fossil fuels used in forest operations, transportation and comminution of forest biomass procured via two kinds of supply chains in Northern Sweden: conventional and integrated. The results indicate that most fuel was consumed in transportation processes. The integrated supply chains (in which the harvesting of industrial roundwood is integrated with extraction of forest fuels) are more energy efficient than conventional supply chains, and have the potential to reduce GHG emissions by approximately 13%.

LCA, energy wood, forest bioenergy

KG I - 1139 (Uni Freiburg)

IUFRO17-2124 **Beetle-killed Biomass for Bioenergy: An Integrated Modeling Approach for Feedstock Supply and Logistics**

Han, H.* (1); Chung, W. (1); Anderson, N. (2)

(1) Oregon State University, Corvallis, United States; (2) Rocky Mountain Research Station, USDA Forest Service, Missoula, United States

Abstract: The recent bark beetle epidemic has affected millions of hectares of conifer forests in the Rocky Mountains in North America. Forest managers are interested in using biomass from beetle-killed trees for bioenergy and bio-based products, but technical and economic uncertainties around the harvest, process, transportation and utilization of beetle-killed biomass lead to a slow response of forest managers to proper management in many private and public forestlands in the region. This study attempts to develop an integrated feedstock logistics model for beetle-killed biomass to address some of the existing uncertainties and information gaps, particularly related to the quantity of available biomass and feedstock supply. This model integrates new allometric equations developed for recoverable biomass of beetle-killed trees, new cost and productivity models for beetle-killed stand harvesting, and new mathematical approach for optimal feedstock logistics. Our results suggest that the new allometric equations of dead trees provide more accurate estimates of recoverable logging residues, and that different tree conditions in beetle-killed stands significantly affect the productivity and costs of harvesting operations. Optimization of feedstock logistics also helps improve the economic viability of beetle-killed biomass feedstock supply.

KG I - 1139 (Uni Freiburg)

IUFRO17-1255 **Optimizing supply of unutilised Swedish biomass to produce torrefied pellets**

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Abstract: Increasing the use of biomass-to-energy is part of the solution in reducing the environmental impact caused by fossil-based energy use. Regionally unutilized biomass can be used to produce torrified pellets at biomass terminals enabling logistical benefits and enhancing product value. The optimization model used in this study rendered the identification of ten terminals in which unutilized primary forest biomass (logging residues, stumps and sawmill by-products) amounting to 4.5 million odt can be transported to and further transshipped or refined into torrefied pellets. The total cost (torrefaction and supply costs) of using only logging residues for torrefaction was 26-30 EURO/MWh depending on terminal location and the size of the torrefaction plant. If stumps are utilized then total costs increase by approx. 20% as the cost of supplying stumps is significantly higher than logging residues. The results are specific to the region of northern Sweden, but three criteria for location of torrefaction plants are suggested: a) Torrefaction plants should be integrated with other industries in order draw advantages from lower production cost. b) Torrefaction plants should be located in areas with abundance of low cost biomass. c) Proximity to existing infrastructure is important in order to minimize cost of distributing torrefied pellets.

logging residues, stumps, torrefaction

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114 - Transforming low grade logs and residues into higher value products through improved supply chain

KG I - 1139 (Uni Freiburg)

IUFRO17-1632 **Forest operations and logistics to reduce costs and improve product value from forest restoration in the southern Rocky Mountains, USA**

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(1) Rocky Mountain Research Station, U.S. Forest Service, Missoula, United States; (2) University of Montana, College of Forestry and Conservation, Missoula, United States

Abstract: The ponderosa pine and dry mixed conifer forests of the southwestern United States are considerably overstocked and prone to destructive wildland fires resulting from the accumulated effects of livestock grazing, fire suppression, insect outbreaks, disease, drought, and climate change. Forest managers in the region are working to increase forest resiliency by moving forest structure and composition toward reference conditions using both prescribed fire and mechanical thinning treatments. Such treatments generate large volumes of small trees and non-merchantable biomass that is most often burned onsite for disposal, which can have negative air quality and site impacts. This paper provides an overview and preliminary results of a three-year research study to examine existing logging systems deployed in the area, and develop and optimize new systems that leverage available logging infrastructure, but also encourage adoption of new technologies and innovative logistics capable of efficiently delivering small diameter logs and biomass feedstocks from restoration treatments to end users such as sawmills, power plants and bioenergy facilities. The team is working closely with logging contractors and existing and potential new end users of woody biomass feedstocks in the region to ensure that the logistics systems under development meet quality specifications and customer requirements.

Restoration, operations, logistics, biomass

All Division 3 (Forest Operations Engineering and Management) Meeting

151 - History, Findings, and Future Directions of Forest Landowner Research

KG I - 1224 (Uni Freiburg)

IUFRO17-1429 **Forest Landowner Surveys in the USA: History, Findings, and Future Directions**

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Abstract: Across the United States of America, 117 million hectares of forestland are owned by 11 million family, individuals, trusts, and estates, collectively referred to as family forest owners. This group controls 36% of the forestland across the USA, more than any other ownerships group, including the Federal government. Operating within political, social, economic, and biophysical constraints, these family forest owners are determining if and how these forests are being managed and what is being produced. To understand these owners and their actions, surveys have been conducted in the USA since the 1940s. The initial efforts were focused on small geographic areas and were often centered on narrow topics. The first national, ownership survey in the USA was conducted in 1993 with subsequent national surveys conducted in 2006 and 2013. The US Forest Service, Forest Inventory and Analysis program conducts these surveys as the social complement to its biophysical inventory. The landownership surveys involve contacting 1,000s of family forest owners from across the USA using a probability proportional to size design and collecting information on land characteristics, reasons for owning, past and future management activities, advice received, concerns, and demographics. The findings show that: family forest owners continue to dominate many landscapes across the USA; the primary reasons for owning are amenity oriented, not financial; most owners are not being reached by traditional programs; and the advanced age of the owners portends the importance of intergenerational transfer of land. Future efforts will allow for longitudinal analyses and deeper exploration of specific topics, such as invasives species, wildfire, and decision-making.

Small-scale forestry

KG I - 1224 (Uni Freiburg)

IUFRO17-1019 **Forest Landowner Surveys in Finland: History, Findings and Future Directions**

Karppinen, H.* (1)

(1) Dept. of Forest Sciences , University of Helsinki, Helsinki, Finland

Abstract: The Finnish economy is highly dependent on non-industrial private forests, which provide around 80% of the domestic timber supply. The first step in creating a permanent monitoring system for private forestry was taken in 1975, and the first round of data collection in the current form was conducted in 1990 followed by two surveys in 1999 and 2009.

Based on these data, several studies on Finnish forest owners and their forestry behavior have been carried out. They have been useful in planning and implementing forestry programs. These studies have concerned owner demographics and holding characteristics, landowners' values and objectives and their forest management behavior. For instance according to the recent timber supply analysis, women sold one cubic meter per hectare and per year less in a five-year period than men did, and they sold less frequently but larger quantities per sale than male owners did. Another study on forest owners' timber stand improvement decisions emphasized the role norm pressures, the main sources of which were the extension officers of local forest management associations, local wood purchasers and family members. Attitudes and perceived controlling factors played smaller roles in explaining stand improvement intention. Especially, female owners and urban owners were more influenced by norm pressures.

demographics, family forests, behavior, objectives

KG I - 1224 (Uni Freiburg)

IUFRO17-180 **Forest Landowner Surveys in Austria: History, Findings and Future Directions**

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(1) University of Natural Resources and Life Sciences Vienna, Institute of Agricultural and Forestry Economics, Wien, Austria

Abstract: Austria is one of the few countries with a long tradition of collecting economic data on forestry by means of forest accountancy data networks. These continuous investigations complement the information of land registers, farm surveys, cutting records and national inventories by monitoring the economic performance of forest holdings. Although the samples are by no means representative in statistical terms, they serve as an invaluable backbone for empirical research and provide detailed insight into the profitability of forestry and the efficiency of operations. Especially the network of bigger forest enterprises (> 500 ha) serves not only sector statistics and politics but is utilized also by many participants for ratio analysis and benchmarking exercises. Meanwhile, the time series cover several decades. The results document developments in terms of intensification of timber production, rationalisation as well as diversification. Safeguarding the considerable resources for running the networks and financing necessary technical modernisations is a constant challenge and relies on the interest and commitment of all stakeholders. Continuous innovations in terms of results and their utilisation are indispensable for sustaining the esteem for this very specific research infrastructure. Just recently, information on small scale farm forestry could be improved substantially by applying models derived from the small network of farm forests to the far bigger and representative agricultural network.

ratio analysis, benchmarking, farm forestry

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IUFRO17-1266 **Forest Owner Surveys in Japan: History, Findings, and Future Direction**

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Abstract: In Japan, two-thirds of the land surface are covered by forests, of which 57% are privately owned. According to the agriculture and forestry census of 2010, the number of family forest owners holding 1 ha or more is 0.9 million, of whom 88% hold less than 10 ha. Thus, private ownership and their small scales characterize the forests in Japan. This study traces the history and findings of forest owner surveys in Japan and discusses the associated issues. The Japanese government established major statistics on private forest owners in the 1960s, a time when Japanese forestry was undergoing drastic changes. Researches and discussions on private forest owners increased in the 1960s and 1970s and heated up during the 1980s. A main issue during this period was the evaluation of small-scale forest owners. After the 1990s, the topics of forest owners' research varied. On the other hand, the targets and items of public statistics on private forest owners diminished especially after the 2000s, and researching forest owners using public statistics has become quite difficult recently. Research focusing on new types of owners is one of the issues that needs to be addressed in the future.

Forest owners, Japan, Family forests, small-scale

KG I - 1224 (Uni Freiburg)

IUFRO17-139 **Unde venis - quo vadis accountancy network - from Fortran to Bayesian network**

Hartebrodt, C.* (1)

(1) Forest Research Institute Baden-Württemberg, Freiburg, Germany

Abstract: The contribution of the development of the Forest Accountancy Data Networks (FADN) in the German context will be retraced.

In the pilot phase of the FADN the leading questions were, which data will be compiled and how a continual system concept must be designed. It can be shown, that the primary role in a second period was the documentation and depiction of various time series of forestry. The continual display of greater amounts of data was more valuable in itself and the knowledge about the different types of forest ownership and their economic behavior was widened. With the switchover to the "world of relational databases" a change was initiated for the use of FADN data. The recurring publications of numerical series were replaced more and more by the requirement to answer individual questions. However, this was also related to the fact that these individual evaluations are often deprived from public viewing and only relevant for a smaller group of people. The visibility of the FADN decreased, which led to a dispute about its role.

Finally, it could be shown that the main legitimation of the FADN had changed. Data was now seen as a source of information and the main objective had become the exchange of data. Side to side with the application of data in international reporting requirements, the use of scientific analysis in political consulting had continually grown, too.

In the last decade an additional option of FADN became evident. The annual data collection provided the opportunity to perform some kind of "side surveys". Thus FADN were used as some sort of "docking device" for additional inquiries.

Shrinking time resources in the participating enterprises led to the most recent changes in the FADN methodology. In a so called modular approach three categories of data were defined: obligatory data, which has to be delivered by each enterprise, optional data and data, which is only relevant for a shorter period and which only covers special topical interests.

Accountancy Network, History, EDP-Technology

KG I - 1224 (Uni Freiburg)

IUFRO17-2340 **Results from the long term Forest Accountancy Networks (FAN) of private forest enterprises in Westfalia-Lippe in Germany**

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(1) Georg-August-Universität Göttingen, Abteilung Forstökonomie und Forsteinrichtung, Göttingen, Germany

Abstract: Multifunctional forestry in Germany is characterized by long production periods and complex biological-technical processes. Private forest enterprises are complex systems which are closely interwoven with the economic environment. To ensure their economic success, forest landowners need to take the economic development into consideration and adapt their management strategies. Thereto long time series data, taken from Forest Accountancy Networks (FAN), can be analyzed.
For over 45 years, data from the FAN Westfalia-Lippe in Germany are scientifically investigated by the department of Forest Economics and Forest Management at the Georg-August-Universit ät Göttingen. The long-term development and adaptation strategies of defined groups of private forest enterprises can be illustrated with these data. These valuable time series information that can support decision-making processes of private forest landowners and consultation in forest policy. In addition, specific parameters that refer to wood species can be compared between different groups (e.g. with different site conditions) and examined in the course of time as well.
This contribution will give an overview over several economic findings of the FAN Westfalia-Lippe in long time series.

forest accountancy network, Cost accounting scheme

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KG I - 1224 (Uni Freiburg)

IUFRO17-1789 **Trends of forest ownership in Lithuania**

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Abstract: In Lithuanian the private forest ownership dominated till Land Reform, which has been implemented in 1920. Private forest owners owned about 65% of total forest area. Since 1938 private forests constituted only 16% of total forest land area. In 1940 private forests have been nationalised by Soviet Governance. Since the year 1991 the forest restitution process started and according to the Forest Act of the Lithuanian Republic, forests are divided into state and private Today, 39.7 percent of the forest area has been restituted to private forest owners, with another 229 000 ha reserved for restitution. Management of state forests are delegated to 42 State forest enterprises and 1 national park. They manage 1,046 thousand ha of forest land.
The analysis of forest ownership trends in Lithuania is based on data of the Centre of Register database and qualitative expert's survey, which have been carried out in the year 2016. The Delphi method have been used for expert's survey. The results of expert's survey showed main trends of forest ownership: 1) expansion of private forests, which are owned by legal entities; 2) foreign investments expansion in private forest sector; 3) changes of private forest owner's types.

ownership changes, foreign investments

KG I - 1224 (Uni Freiburg)

IUFRO17-3247 **Shaping forest owners behavior through norm sending structures and educational processes - the Swedish case**

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Abstract: Due to more alienated and fragmented ownership, in Sweden as many other European countries researchers and authorities have raised concerns regarding non-industrial private forest (NIPF) owners' interest and ability to produce timber for industrial purposes. However, when looking at management behavior of NIPF:s in Sweden, the level of timber harvesting and silvicultural measures demonstrate a continuously high level of activity although the working hours in self-employment has fallen to half of what it was three decades ago. This calls for a critical analysis of the research assumption that structural and attitudinal changes within the NIPF ownership corps, will result in a falling interest to manage the forest for timber production. According to our analysis, the market and the technological development have been able to deal with fragmentation and less ownership involvement in the management. Further, the norm sending structures and educational process established through the Swedish forestry model of "freedom with responsibility", still works in order to promote timber production. Yet, the balance between the main actors of the Swedish forestry model - the state, the forest industry, and the NIPF owners - has shifted towards more of industrial and market influence. Accordingly, NIPF owners' behavior will increasingly depend on the advices and services offered by the forest industry.

attitudes, behaviour, norms, NIPF-owners,

KG I - 1224 (Uni Freiburg)

IUFRO17-364 **Describing non-industrial private forest (NIPF) owners through their forests - an application of the place attachment framework**

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Abstract: Forest ownership in Estonia is very diverse as there is more than a million hectares of private forests, which is managed by more than 100 000 private owners. Most of them are non-industrial private forest (NIPF) owners. Information about the needs and characteristics of these forest owners is scarce as to date, there have been no studies focusing on NIPF owners in Estonia. However, considering the recent trends in private forest ownership and their policy significance, it is important to understand the management rationale of these owners. We intend to increase this knowledge base by having a qualitative approach to the study. These methods are explorative and do not allow to test any formed hypothesis nor do they allow to make larger-scale generalizations. Instead, we focus on having a rich, in-depth set of data, which would enable us to look at the subjective feelings of ownership, as they are much more than just legal entitlements. The data has been gathered by interviewing NIPF owners (to date there are 8). The interviewees were reached through personal connections or through some key informants. The interviewees were chosen mainly according to the property size criteria, as our aim was to have a small-scale forest owner's perspective (-20 hectares). We use cross-case content analysis for the transcribed interviews in order to identify the variables of place attachment and the owners' motives and objectives in the transcribed interviews. We follow the three-dimensional framework of place attachment developed by Scannell and Gifford (2010)*. This enables us to open up a triangular relationship with the forest owner, forest property and psychological processes. Such an approach could better explain for example how different ownership motives actually realize or from where some objectives for forest ownership come from.

* Scannell, L., Gifford, R. (2010) Defining place attachment: A tripartite organizing framework. Journal of Environmental Psychology 30(1): 1-10.

Estonia, forest management, qualitative, interview

All Division 3 (Forest Operations Engineering and Management) Meeting

151 - History, Findings, and Future Directions of Forest Landowner Research

KG I - 1224 (Uni Freiburg)

IUFRO17-3477 **Understanding small woodland owners and managers in the UK: evidence to promote resilient behaviour change?**

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(1) Forest Research, Farnham, United Kingdom; (2) Forest Research, Northern Research Station, Roslin, Edinburgh, United Kingdom

Abstract: Around 73% of woods in the UK are in private ownership: 35% of those woodlands are less than 20 hectares in size, and the majority are owned or managed by non-industrial or family foresters. The UK does not have a tradition of national forest owner surveys. Policy makers and sector stakeholders tend to commission topic focused research to better understand these small scale owners. The policy priority is to influence their behaviour, specifically to a) increase their active management of woodland, and b) in ways that are resilient to biophysical and socio-economic change.

We present our latest UK-wide research exploring woodland owners understanding of resilience. This follows on from a UK-wide bi-annual survey, the British Woodland Survey. We undertook additional extended interviews with around 50 small woodland owners and managers. Our sampling was informed by a segmentation model based on owners values and management objectives. Findings show that whilst understandings of resilience vary between woodland owner types, there are common issues of particular significance. For example: around 50% of owners were unsure if believe climate change will have an impact on their woodlands; if they perceive any threat there is high uncertainty and they believe there is little they can do to mitigate change; that many have a desire to plant resilient tree species, but different and sometimes contradictory guidance and messages on how to manage forests for resilience increases their reticence to change. One of the major barriers to behavioural change continues to be appropriate communication pathways and learning opportunities.

We use our findings to suggest future directions for forest land owner research in the UK. We comment on how far research evidence can influence policy responses and move beyond the focus on grants as the only route to influencing small woodland owner behaviour.

woodland owners, resilience, behaviour change,

KG I - 1224 (Uni Freiburg)

IUFRO17-3770 **Spatially-explicit analysis of forest landowners**

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Abstract: Data sources on private forests and forest owners are of different spatial and temporal resolution. The large-scale periodic forest owner surveys provide continuous data on private forest owners in only few countries. Most countries rely on case study analyses or surveys limited to smaller areas, or they monitor private forests and their owners through aggregate, statistical indicators such as the aggregate environmental, economic and social indicators in forests in the European Union. In addition to the lack of reoccurring representative surveys of forest owners, the key problem is that surveys and accountancy networks do not allow for spatially explicit analyses. This is either due to anonymity of respondents in the case of large-scale representative sampling, or because of unrepresentative sampling in smaller case study areas. We developed a spatially explicit explanatory model of public concern for forest protection in Slovenia based on a representative sample of adult citizens (n = 1006 completed telephone interviews of which n = 264 private forest owners). The model analyzed how personal and socio-economic attributes of citizens, landscape attributes of the area surrounding their homes, and their general proenvironmental orientation influence their concern for forest protection. We found out that proenvironmental belief is a strong predictor of the concern for forest protection, although landscape attributes play also an important role in improving the understanding of human behavior. We showed that quantitative surveys of private forest owners have the potential to be upgraded to a spatially-explicit analysis of private forest owner behavior in which many additional predictors of private forest owner behavior can be obtained by the aid of the geographical information system.

NIPF owners, survey, quantitative methods

All Division 3 (Forest Operations Engineering and Management) Meeting

202 - Eco-friendly harvesting operations in mountainous terrains

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3656 **Cable tension monitoring and setup time of winch assisted single-grip harvesters and forwarders in steep terrain operations**

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Abstract: Effectively running and organizing timber harvesting operations in steep terrain is a complex task and is still under pressure by costs and time consuming processes. Especially fully mechanized harvesting operations require high productive, specialized and costly machinery including skilled and well trained operators. Winch assisted harvesting machinery offer new opportunities in terms of cost efficiency and safety issues on steep terrain including aspects of avoiding soil disturbance and decrease slip on the skid trail.
The objective of this study is firstly to setup a study layout for cable tension monitoring depending on actual harvesting activity in combination with machine inclination. Additionally set up time for cable assisted machinery on steep terrain should be investigated to enable more accurate estimation of additional installation effort and to improve existing pre-calculation routines for timber harvesting cots of fully mechanized harvesting operations in steep terrain.
Cable tension monitoring equipment and developed analysis routines worked out well. Average set up time for winch assisted harvester and forwarders uses between 8 to 9 percent of the whole operation with regard to productive system hours without delay. The safe working load of 50% of the used cable was not exceeded during whole monitoring activities.

cable tension monitoring, steep terrain harvesting

K 2-4 (Konzerthaus Freiburg)

IUFRO17-257 **Forest Operations in Environmentally Sensitive Areas in Europe and the United States: A perspective**

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Abstract: This presentation offers a perspective on forest operations in environmentally sensitive areas in Europe and the United States. The objective is to explain key sustainability knowledge gaps in forest operations and management considerations to reduce impacts in these increasingly targeted and difficult to operate in areas. Ecosystem services linked to soil, water, wildlife and biodiversity receive high consideration from guidelines and best management practices perspectives. However, the operations in connection with these areas are rarely well articulated. One means to address the operations in these sensitive conditions is the selection of equipment and work methods driven by terrain type, forest features and management objectives. This paper discusses the environmental, planning, equipment and supply chain considerations and proposes possible solutions and guidelines to contain operator, technological and environmental risks.

critical environments, equipment, ecosystem

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1224 **Short span logging cable systems in steep terrains: Running skyline and simple standing skyline systems oriented for small scale forestry**

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Abstract: One option to overcome steep terrain without slope failure is using narrow roads combined with small scale logging systems. There exist two popular such logging cable systems in Japan. The first one is running skyline system rigged up with Japanese style swing yarders, and the second one is simple standing skyline system with a winch mounted mini-forwarders. These systems have two advantages: low machine price and simple rigging methods. Both systems are based on commonly used machines which one can purchase reasonable prices. However there is one disadvantage, low operational efficiency, of which in some cases it would be prevented through self-employment or family based occupation. Such low efficiency is partly due to simple mechanism of the carriages. Precise analysis of rigging methods may reach to fundamental refinement of the system. The present paper at first overviews the classification of rigging methods including conventional logging cable systems. Then by analyzing force balance around carriages of the systems, possible modification will be proposed for enhancing the operational efficiency. This research was funded by JSPS KAKENHI Grant Numbers 16K07779 and 15H04508.

cable system; rigging; road network; steep terrain

All Division 3 (Forest Operations Engineering and Management) Meeting

202 - Eco-friendly harvesting operations in mountainous terrains

K 2-4 (Konzerthaus Freiburg)

IUFRO17-669 **Automatic harvest and cable road layout planning for multiple objectives**

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Abstract: Cable-yarding is the most common technique for harvesting timber from steep terrain in Central Europe. During the planning process, one important task is to define the cable road layout. This means that the harvesting technology and cable road location must be specified for a given timber parcel. Although managers must minimize harvesting costs, it is even more important that such work on the forest reduces the potential for damage to the residual stand, and ensures that environmental conditions remain suitable for regeneration. Because all existing optimization tools were developed for clear cut harvesting activities, they do not incorporate the objective to minimize the negative impacts to residual trees, but are geared only toward reducing harvesting costs.
We present an Mixed Integer Linear Programming (MILP) approach for designing an optimal harvest plan that focuses on placement of cable towers and cable roads and that is appropriate for multifunctional managed forest in steep terrain. It minimizes concurrently the negative ecological impacts and the harvesting costs. The model was test on a site at the Rigi mountain in Switzerland. The study produced the following major findings: First, single-objective alternatives proved to have no practical relevance whereas the multi-objective alternatives (including ecological objectives) are preferable in real-world applications and lead to realistic solutions. Second, we suggest that the solution process for a planning unit should include the analysis of the Pareto frontier. And third, calculation time was significantly reduced when 1) considering multiple objectives and / or 2) applying a simplified model. The simplified model was able to find the optimal solution in most cases.

Steep Terrain Harvesting, Optimization Models

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2274 **A spatially explicit harvest scheduling model for optimal management of rockfall protection forests**

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Abstract: A forest on the hillslope can stop a remarkable share of falling rocks and thus protect lives and human assets from damage. Optimal forest states can be specified based on the knowledge about forest-rockfall interactions. Those states change with rock size, e.g., a high stem number of relatively small trees (like a thicket) is preferred for small rocks whereas trees in the timber stage are preferred for bigger ones. Foresters aim at including that knowledge into their management decisions. Since forest is a dynamic system where the forest state inevitably changes over time, a sustainable management scheme must be identified which provides a continuously high protection effect against rockfall. This requires the spatially explicit scheduling of forest treatments under the consideration of various harvest intensities. Here, we propose a spatially explicit harvest scheduling optimization model for a rockfall corridor where the continuous protection effect is maximized subject to the sustainable renewal of the forest. A matrix population model is used to model forest dynamics. The corridor is discretized into treatment units, and constraints are introduced to control dependencies between adjacent units. The resulting optimization model is tested on an hypothetical forest corridor.

rockfall, harvest scheduling, natural hazard

K 2-4 (Konzerthaus Freiburg)

IUFRO17-101 **Cable logging in the Italian Alps: survey of operations and machine fleet, business perspectives and contract rates**

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Abstract: The rapid increase of global population is causing a considerable growth of fiber demand and it is pushing wood production towards increasingly difficult terrain, as flat land is being monopolized by farming and urban development. In the mountains, cable yarding remains the most common, effective and environmentally-sound harvesting system, despite the rapid progress of winch-assist technology. Cable yarding is well established on the Italian Alps, and one can draw much useful information from the Italian experience. In the Italian Alps there are about 350 enterprises who manage cable yarders, of which one-third is represented by modern tower yarders, and two-thirds by an array of old and new sled-winch models. This paper will offer detailed information about company demographics and machine fleet, for the whole pool of enterprises. Furthermore, the paper will explore the financial performance and perspectives of a sample of these enterprises, including their perceived success factors and hurdles to further business success. In that regard, a comparison will be drawn with enterprises resorting to ground-based technology. Finally, the paper will offer information about the actual contract rates of cable yarding, offering a comparison with: 1) the rates charged by ground-based crews in Italy, and 2) the rates charged by cable-yarding crews in other countries in the Alpine space (e.g. France, Germany, Slovenia, Switzerland). These results have been obtained through the analysis of 904 actual contracts, executed in the Alps between 2010 and 2015.

technology; cost; profitability; hurdles

All Division 3 (Forest Operations Engineering and Management) Meeting

117 - Sustainable forest operations for forest and landscape restoration

KG I - 1139 (Uni Freiburg)

IUFRO17-2091 **An early crop tree release approach as a cost effective means of restoring hardwood stands in a Canadian context**

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Abstract: Harvesting practices in some hardwood stands of eastern Canada generate thousands of hectares of less productive stands annually. The strong dominance by non-commercial and low value species combined with the low stocking of desired species in those regenerated stands renders traditional stand tending silviculture operations financially unviable. In an attempt to find a cost effective means of steering such stands back towards a more productive and acceptable state, an unconventional early crop tree release intervention was tested using a clearing saw designed for top spacing. The trial was conducted in a 16-year old stand of clearcut origin. Presence of desirable species was highly heterogeneous, with more than 30% of the area not regenerated at all and another 20% not stocked with desired species. Tree heights varied from 4 to 12 meters high. Treatment focused on the release of only the well-formed and vigorous trees of the desired species from competing vegetation. Worker productivity (area treated per productive hour) compared to that of a traditional precommercial thinning, was increased by 250% to 700%, resulting in significant cost reduction. The improvement was attributable to two factors. First, the treatment is less intense due to the focus on high quality trees of the desirable species compared to the usual release of the relatively best tree at a regular interval. Second, the equipment used was better adapted than traditional clearing saws, allowing for fast and easy travel within the untreated portion of the stand and, allowing to cut larger stems efficiently. It is expected that this release of desired species will increase their chance of survival and will accelerate the recovery towards pre-harvest conditions. Such a cost-effective approach may justify restoration treatments within regular silviculture budgets. The results and observations from this first trial also suggest that this approach could be useful in other forest restoration contexts.

thinning; productivity; spacing; poor stocking

KG I - 1139 (Uni Freiburg)

IUFRO17-1859 **What does landscape restoration at scale of Initiative 20x20 mean for FLR operations in Latin America?**

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(1) World Resources Institute, Washington DC, United States

Abstract: Initiative 20x20 is a country led platform to bring under restoration 20 million hectares of degraded land in Latin America by 2020. Today, Initiative 20x20 has 27.7 million hectares of restoration pledges from 11 countries, three Brazilian states and three regional programs. The Initiative's objective is to contribute to reduce and revert land degradation in Latin America and the Caribbean. This effort supports the global land-restoration efforts of the Bonn Challenge and the UNFF New York Declaration. The 20x20 was launched by eight countries and five private investment groups at COP 20 in Lima, Peru in December 2014. The landscape restoration activities under the initiative aim to restore degraded land functionality to increase social wellbeing while improving environmental conditions and generating financial and economic benefits. Strategies may include, but are not limited to, agroforestry, tree plantations, silvopastoral systems or silvicultural management of degraded and secondary forests. The restoration at the scale of Initiative 20x20 will require efficient, cost-effective and sustainable forest operations. Forest operations include site preparation, planting, maintenance, harvesting and transportation. In this presentation we will be discussing the operational challenges in the Latin-American region to restore degraded land. We will focus in different value chains from potential products of the restored land to analyze the links between forest operations, restoration and rural development. Typical forest operations are being carried out across the region but restoration may require the adaptation of some of those techniques to the challenges offer by the degradation level and type of intervention. The understanding of forest operations is key to address cost-effective restoration strategies in the landscape.

Landscape Restoration economics forest operations

KG I - 1139 (Uni Freiburg)

IUFRO17-495 **Automated volumetric measurement of truckloads through multi-view photogrammetry and 3D image reconstruction software**

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Abstract: Given that wood represents on average about 1/3 of the delivered cost, it is key to adopt correct measurement procedures and technologies that provide better wood volume estimates. Poor measurements not only impact the revenue obtained by haulage contractors and forest companies, but also might affect their contractual business relationship. Although laser scanning has become a mature and more affordable technology in the forestry domain, it still remains expensive to adopt and implement in some real-life operations. In this study, multi-view photogrammetry and commercial 3D image reconstruction software were tested as an innovative and alternative method for automated volumetric measurement of truckloads. Multi-view 3D reconstruction is an inexpensive, effective, flexible, and user-friendly photogrammetric technique for obtaining high-resolution datasets of complex topographies at different scales. About 76% of the variation of solid volume was explained by the frame volume calculated from Multiview 3D reconstruction. These preliminary tests show promising results for the future implementation of this approach in real operating conditions, and more tests will be conducted to validate this volumetric measurement approach.

Photogrammetry, 3D reconstruction, frame volume

All Division 3 (Forest Operations Engineering and Management) Meeting

201 - Sustaining the emerging bioeconomy - Innovations in forest harvesting & transportation

KG I - 1139 (Uni Freiburg)

IUFRO17-1503 **Productivity and cost of cable-assisted felling and extraction in the Pacific Northwest, USA**

Green, P.* (1); Chung, W. (1); Crawford, R. (1); Garland, J. (1); Leshchinsky, B. (1); Sessions, J. (1); Wimer, J. (1)

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Abstract: Logging and timber falling in the Pacific Northwest continue to be one of the most dangerous jobs in the United States. Mechanization for steep slope harvesting may be successful in reducing logging-related accidents and provides operators the ability to continue working in the face of an aging and declining workforce. However, with such a significant capital investment required of forestry heavy machinery, productivity and cost models are often given heavy consideration when determining both economic and operational feasibility of a harvesting system. This study has two main objectives. The first is to develop four different productivity and cost (hereafter denoted as P&C) models of current and new harvesting systems used in the Pacific Northwest with several different measurable external independent variables. The second objective is to be able to make comparisons at a harvest-unit scale between the four systems through not only P&C analysis, but also between safety and environmental impacts. Safety and environmental impacts are out of the scope of this specific study, but anticipated to be addressed through collaboration with other studies. The four different systems analyzed are: 1) conventional hand-falling with both tower-yarding and grapple yarding as the extraction method, 2) cut-to-length harvesting with a cable-assisted harvester/forwarder, 3) cable-assisted feller-buncher machine paired with a tethered skidder for extraction, and 4) cable-assisted feller-buncher machine with grapple yarding. The overall goal of this ongoing research is to be able to optimize harvest layout and system design. From haul route locations, to skyline corridors needed, all aspects will go into unit layout planning. It is the intention of this study is to give contractors and landowners tools necessary to design steep-slope harvesting operations efficiently and safely in a systematic and efficient way.

Productivity/cost, cable-assist tech.

KG I - 1139 (Uni Freiburg)

IUFRO17-2854 **Roll over protective structure for quad bikes**

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Abstract: World-wide, Quad bikes are used by many private wood lot owners and farmers in work like transportation of equipment, seedlings or fire-wood, or just to get out to the work place. Unfortunately, the risk of accidents when driving a quad bike is high. In Sweden about 6 persons per year are killed in Quad bike accidents, in Australia about 13 persons. About half of the fatal accidents are work related. The other half is recreational related. The quad bike has rolled over in a majority of all fatal accidents. Studies on stability, dynamic handling and rollover crashworthiness has demonstrated the importance of a roll over protective structure (ROPS), if quad bikes at all can be recommended for work activities. Such ROPS has to protect in rear, front and (most often) lateral roll over, without reducing the stability on the vehicle and without hindering an operator in driving. This is difficult to reach, since a quad bike is small (1.2 m wide, 350-450 kg) and the operator often drives both sitting and half standing. A number of ROPS have been tested, and a new design will be presented, aiming to fulfil basic rollover crashworthiness demands, and practical needs in work activities.

ATV, occupational safety, chest and head injury

KG I - 1139 (Uni Freiburg)

IUFRO17-3481 **Education in safe chainsaw usage and its long term effects**

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(1) Swedish University of Agricultural Sciences, Umeå, Sweden

Abstract: Injuries are serious problems in motor-manual forest work. For prevention, a formalized training and examination called "Motorsågskörkortet" (chainsaw license) was developed 14 years ago, and is since 2015 legally required when professionally using chainsaws in Sweden. The license has 10 levels, with the levels A and B covering normal forest work such as felling, delimbing and cross-cutting. The study aim was to investigate the long term effects of the license on the user's knowledge and risk awareness in chainsaw work. A questionnaire was sent to 3,000 holders (professional users and non-industrial forest owners) of the license. Results show that, when redoing the theory tests 1-9 years after license approval, 75% passed on level A but only 52% passed at level B. Moreover, time since license approval did not influence the re-test results. Ninety-nine percent said that they became safer in their chainsaw usage due to the license education, out of which 30% had become much safer. Women did to a greater extent than men consider themselves to work safer after the license. We conclude that the chainsaw license fill an important role to increase safety in motor-manual felling for both professional users and non-industrial forest owners.

Certification Chainsaw License Safety "Säker Skog"

All Division 3 (Forest Operations Engineering and Management) Meeting

209 - Safety and Health in Forestry

KG I - 1139 (Uni Freiburg)

IUFRO17-851 **Drivers and barriers for effective health protection and accident prevention in small and micro service enterprises in forest operations**

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Abstract: Many research findings and statistics affirm that forestry work is characterised by high accident risks and serious health hazards. Forest ergonomics and forest engineering provide manifold technical, organisational, and behavioural measures to reduce accident and health risks. Whereas permanent research is needed to continuously improve prevention measures, keen knowledge about effective protection of workers' health and the prevention of accidents is available, both in research and practice. But in many enterprises available prevention measures are not effectively used, particularly in small and micro enterprises.

To improve safety and health it needs to be understood why prevention is a shortcoming in one enterprise, or why and how it works successfully in another. The first phase of a three year research project was dedicated to assess the situation in forest enterprises for identifying drivers and barriers for effective prevention. The study was carried out with in depth interviews with entrepreneurs and forest workers and workplace observations.

It is obvious that the conditions between forest enterprises are very heterogeneous. Generally, the core barriers for prevention are not the lack of knowledge, skills, and health awareness. It is rather a multifaceted complex of structural, organisational, motivational and economic factors, which distract entrepreneurs from implementing safety and health measures. Further, the general acceptance of safety rules and regulations and of obligatory request for technical protection is often replaced by individual, situative decisions to take and accept risks.

A better understanding of the conditions in small and micro enterprises and the attitudes and motivation of entrepreneurs forms the basis to develop health protection and accident prevention concepts that will be accepted and applicable under the specific conditions of small and micro enterprises, and that will last but not least be economically affordable.

Safety and Health, Prevention, SMEs

All Division 4 (Forest Assessment, Modelling and Management) Meeting

112 - Climate change adaptation in forest management: from applied science to implementation

K9 (Konzerthaus Freiburg)

IUFRO17-1095 **Integration of climate and ecological modeling tools for adaptive management in Asia-Pacific forests**

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Abstract: Climate change is a threat to the stability and productivity of forest ecosystems. Potential changes to or loss of forests will have drastic environmental impacts on biodiversity, ecosystem function and resilience, and socio-economic impacts on economies dependent upon them. Despite their importance, a lack of information and tools focused on Asia-Pacific ecosystems and economies exists, which are necessary to understand potential effects of climate change and develop regionally-specific adaptation strategies. The project Adaptation of Asia-Pacific Forests to Climate Change aims to address this lack of knowledge and tools, and to increase the adaptive capacity of Asia-Pacific forest ecosystems. This objective has been achieved through: development of a high-resolution climate model (ClimateAP) applicable to the region; development of ecological models to project how climate change will affect suitable conditions, regeneration, and productivity of tree species; development of tools to assess local management strategies based on objectives; evaluation of models to assess forest fire risk and frequency; assessment of ecosystem carbon storage using LiDAR; and evaluation potential vegetation dynamics responses to climate change using remote sensing technology. Project outputs were developed considering ease of communication, necessary for findings to be implemented in effective policy and adaptive forest management strategies.

climate change, climate model, ecological model

K9 (Konzerthaus Freiburg)

IUFRO17-3988 **Climate change, adaptation and management of risks to boreal forests**

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(1) University of Eastern Finland, Joensuu, Finland; (2) Natural Resources Institute Finland, Joensuu, Finland; (3) Finnish Meteorological Institute, Helsinki, Finland

Abstract: Under the projected climate change, the mean annual temperature may increase in Northern Europe until 2100 by 3-6 C ° and mean annual precipitation by 11-18% compared to the current climate. As a result, the carbon sequestration and wood production are expected to increase in boreal forests. This is because currently short growing season, relatively low summer temperatures and small supply of nitrogen limit them. The carbon sequestration and wood production are expected to increase in relative sense also more in northern than in southern boreal conditions, where the growth and success of tree species like Norway spruce with shallow rooting may suffer drought especially on sites with low water holding capacity. The future development of forest resources is affected both by the current forest structure (age, tree species), intensity of forest management and projected climate change together with associated increase of various abiotic and biotic risks to forests. Climate change is expected to increase the risk of forest damages, e.g. by wind storms, bark beetles and fungus especially in Norway spruce. Risk of wind damages are expected to increase in boreal conditions despite of increase of windiness, due to the increase of duration of unfrozen soil during the most windy season of year, i.e. from late autumn to early spring. This is because frozen soil improves tree anchorage. However, various damage risks to forests may be decreased at least in some degree by considering them in forest planning (i.e. using optimised management plans). Similarly, forest ecosystem and mechanistic risk models could offer useful means to evaluate how intensity of forest management and projected climate change may affect together the risks to forests. As a result, proper adaptive management strategies could be developed, considering the uncertainties related to the projected climate change.

Climate change, risk management, bioeconomy

K9 (Konzerthaus Freiburg)

IUFRO17-4149 **Economic adaptation of silviculture and forests to climate**

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Abstract: Adaptation to climate change is essential for forests that experience global warming. This warming will be between +1.5 °C and more than 6°C depending on the climate scenario and the time horizon. The forest manager has to decide today on a part of each forest which species should bear not only present but also future conditions (average and extreme temperatures, rainfalls, winds, sanitary conditions...). This is not easy and should be supported by appropriate tools. EASYFORCLIM, is a web tool that deals with even-aged monospecific stands and could then be adapted to other circumstances. It is structured around a biophysical and economic model that takes into account (i) a reference growth for the site and the species under the present known conditions considered as stable; (ii) a reference economic context under the same conditions; (iii) a set of plausible future climates at global and local scale; (iv) the stand productivity response to climate change; (v) the catastrophic risk with its reference probability and evolution under climate change; (vi) the economics of timber resources under climate change; (vii) the economics of carbon sequestration and avoided emissions under climate change. The objective is to estimate the land expectation value under several local climate scenarios in order to identify the acceptable range of rotation age in each case. The economic analysis allows here to consider simultaneously trends and extreme events, private and public goods, different trends (growing or decreasing) along the stand life. It finally provides a measure to support decisions about the chance for the stand to reach or not the maturity. The approach is a generic one and the model requires some parameters only, that can be taken from scientific literature or expert opinions. The presentation will be based on an example, will discuss the interests of the approach and its limits, and will suggest the more crucial needs from scientific studies.

Climate change, adaptation, modelling, economics

All Division 4 (Forest Assessment, Modelling and Management) Meeting

112 - Climate change adaptation in forest management: from applied science to implementation

K9 (Konzerthaus Freiburg)

IUFRO17-1963 **Knowledge transfer in applied climate change adaptation research: lessons learned from regional case studies across Europe**

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Abstract: Climate change may strongly impact on forests and affect the provisioning of forest ecosystem services. The identification, design, selection, and implementation of adaptive measures in forest management require a sound knowledge base as well as tools to support forest managers and stakeholders in decision-making. To foster the development of "useful knowledge" and to close the gap between science labs and users of scientific knowledge, participative and collaborative applied research projects have been promoted for more than a decade.
In this contribution we use the network of a dozen regional case studies from two EU FP7 projects (ARANGE, MOTIVE) having been implemented between 2009 and 2015 to evaluate the "usefulness" of research results, the knowledge transfer process and the uptake by endusers from the perspective of involved scientists, forest managers and stakeholders. Based on data and information including in-project documentation, available publications, and post-project interviews with managers and stakeholders from the case study regions we contrast the employed scientific methods and tools and the interaction mode between scientists and endusers during and after the project with the expectations of endusers and the achieved results. Factors determining success or failure are identified and proposals are made how to improve knowledge transfer and implementation in applied forest adaptation research.

knowledge transfer, regional case studies

K9 (Konzerthaus Freiburg)

IUFRO17-3527 **Mind the gap: How to bridge between scientific possibility and practical necessity in adaptive mountain forest management**

Bugmann, H.* (1)

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Abstract: Over the past 15 years, the skill of dynamic forest models (DFM) has increased considerably with respect to capturing key climate-dependent processes while augmenting in local accuracy, thus making their results potentially useful for guiding adaptive forest management. I will report and synthesize Swiss case studies in which simulation results from DFMs were exposed to forest managers, and will evaluate the success (or lack thereof) regarding the actual application of DFM-based information.
On the one hand, there appear to be limits to what can be achieved in a modeling context: making models locally highly accurate is inevitably bound to a loss of generality or applicability under climate change conditions. I will try to sketch what I perceive to be the maximum skill that can reasonably be expected from DFMs. On the other hand, there appear to be limits to the level of detail (or lack thereof) that is acceptable to forest managers. However, this latter limit depends strongly on the scale at which management decisions are happening - from local to district and national scales. I will try to generalize the observed responses into a synthetic picture of the width of the gap, and ways to narrow it (further).

Stakeholder dialogue; Decision support; Modeling

K9 (Konzerthaus Freiburg)

IUFRO17-1928 **Utilizing forest tree genetic diversity for adapting forest to climate change: a transnational approach**

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(1) Austrian Research Centre for Forests, Vienna, Austria

Abstract: Since climate conditions are considered to be major determinants of tree species' distribution ranges and drivers of local adaptation, anthropogenic climate change (CC) is expected to modify the distribution of tree species, tree species diversity and the forest ecosystems connected to these species. The expected speed of environmental change is significantly larger than the natural migration and adaptation capacity of trees and makes spontaneous adjustment of forest ecosystems improbable. Planting alternative tree species and utilizing the tree species' intrinsic adaptive capacity are considered to be the most promising adaptation strategy. Each year about 900 million seedlings of the major tree species are being planted in Central Europe. At present, the utilization of forest reproductive material is mainly restricted to nationally defined ecoregions (seed/provenance zones). But when seedlings planted today become adult, they might be maladapted, as the climate conditions within ecoregions changed significantly. In the cooperation project SUSTREE, we develop transnational delineation models for forest seed transfer and genetic conservation based on species distribution models and available intra-specific climate-response function. These models are being connected to national registers of forest reproductive material in order to support nursery and forest managers by selecting the appropriate seedling material for future plantations. In the long-term, European and national policies as well as regional recommendations for tree provenance use need to be adapted to consider the challenges of climate change.

assisted gene flow; SDM; provenance; seed transfer

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K9 (Konzerthaus Freiburg)

IUFRO17-1748 **Can the Norway spruce timber supply be reduced by silvicultural treatments?**

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Abstract: There is supposed a relative strong decrease of the coniferous timber supply due to changes of tree species composition in the Czech forests and due to the environmental changes. The Norway spruce (Picea abies /L./ Karst.) is the most affected species. The annual timber supply decrease of this species is supposed in an extent of 0.9 mil. m3 in the next two decades (2013 - 2032) and more than 1 mil. m3 decrease is supposed for all conifers. There are several option how to mitigate this decline. Plantation of Douglas-fir (Pseudotsuga menziesii /Mirb./ Franco) can substitute N. spruce on part of its today sites and so eliminate partially the timber supply decline in the future. The cultivation of Douglas-fir could lead to increase of the plantation area from 5,800 ha (today) to the extent of 149,616 - 163,713 ha respecting legislative restrictions and recommendations of general management plans. This can represent increased timber increment of 300,000 - 650,000 m3 per year. Secondly, the use of commercial fertilisation on 10% of regenerated Norway spruce stands can lead to an increase of timber supply by 240,000 m3 annually. Finally, the use of selection pronciples at regeneration of the Norway spruce stands in comparable extent can result in another 200,000 m3 annually. All these attempts can substantially mitigate the coniferous timber supply decline in the next decades.

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130 - Contributions of Forest Mensuration and Modeling over 125 years

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2292 **Reflections on the contributions of Bertil Matern**

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Abstract: Some rightfully credit Bertil Matérn's 1960 publication of Spatial Variation as launching the modern era and interest in spatial statistics. Implied in the subtitle to this famous publication is Matérn's interest in forest inventory, and forest sampling more broadly. Indeed his monograph was initially published as a volume by the Swedish Forest Research Institute. Matern also hosted Peter J. Diggle during his sabbatical leave from the University of Newcastle upon Tyne in 1978. Together they made significant advances leading to articles on the developing field of spatial point pattern analyses. Matern proposed line intersect sampling to estimate linear features of maps, such as lengths of roads, in a day before GIS generated such information at the push of a key. Of course, the legendary 1956 monograph "On the geometry of the cross-section of a stem" has long been regarded as a hallmark analysis of this very basic of all tree measurements. This presentation will be a brief retrospective look at this inspirational statistician, who always regarded himself, first and foremost, as a forester.

spatial variation, stem cross-section, SPPA

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1461 **Long-term expansion in the growing stock of the French forests : analysis and modelling**

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Abstract: After centuries of decrease, most developed countries including France have been experiencing a forest area increase for decades, a shift called "forest transition". A far less described but faster expansion in growing stock (GS) is also occurring. Little is known about it, how it varies across contexts (geography, ownership, forest composition). National Forest Inventory (NFI) data and ancient forest statistics (e.g. 1908/1929) can make a useful contribution to inform these changes and deliver key information for forest policy.

We investigated trends in forest area and GS by 'department' administrative unit (dau), ownership and forest composition. Acceleration in area and GS increase was also explored. A statistical modelling approach of GS expansion was attempted, aimed at relating GS variation to initial GS, recent area expansion, current area losses and GS density in the different contexts, using GLS regression models. We also report ongoing developments on GS budget computations over the NFI cycles, and on large-scale demographic models including area changes, forest composition partitioning and density-dependence processes, aimed at understanding the GS expansion processes.

Between 1976 and 2012, almost all dau exhibited an increase of their forest area and GS. Private and communal forests showed the same relative increase of area whereas State forests exhibited a lower one. But, GS increased much faster in private than in public forests and accelerated in private forests, especially in broadleaved ones, while the increase of area was constant. Statistical models of GS variations accounted for 45% of the country forest changes and >50% in private broadleaves forests. They showed that GS expansion mostly depends of initial GS (+), GS density (-) and, to a lower extent, of recent area increase (+) and current area losses (-). These results form a baseline for in-depth analysis of GS expansion based on demographic models.

expansion, growing stock, NFI, modelling

K 5-7 (Konzerthaus Freiburg)

IUFRO17-637 **Forest sampling viewed in the context of stereology and Monte Carlo integration**

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Abstract: Many sampling techniques used in forest mensuration and inventory can be considered to be within the framework of stereology and Monte Carlo integration. Stereology uses one dimensional probes or two dimensional slices to estimate properties such as volume of three dimensional objects. One dimensional probes or dimensionless points can also be stereologically applied to the estimation of properties of two dimensional constructions such as land areas. Monte Carlo integration utilizes lines or points randomly located within the domain of an integral to estimate the value of the integral. When the concept of the inclusion area is applied to Bitterlich sampling, estimation of basal area per hectare could be considered under the framework of stereology as estimation of areas using randomly located dimensionless points. Under the framework of Monte Carlo integration, Bitterlich sampling is "hit or miss" sampling, which utilizes randomly located points to estimate the value of an area which could be expressed as an integral. Other sampling methods such as line sampling, plot sampling, critical height sampling and importance sampling can be considered within the frameworks of stereology and Monte Carlo integration.

Forest inventory, tree volume

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K 5-7 (Konzerthaus Freiburg)

IUFRO17-2928 **Models and their role in assessing the carbon dynamics of forests**

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Abstract: National and international reporting systems (e.g. the submissions under the UNFCC and the Kyoto protocol, studies on forest biomass or carbon potential or REDD+ reporting) require information on biomass and/or carbon stocks in forests. For this purpose different modeling approaches based on different input data sets are developed and/or in place to assess the carbon stocks and carbon dynamics of forest ecosystems. This presentation compares different modeling approaches to derive carbon estimates based from (i) National Forest Inventory data using biomass functions or conversion factors (ii) Flux tower data, and (ii) an the remotely sensed MODIS satellite driven carbon estimates. We compare the different methods show how different modeling tools are used according to the data sources. The results of the study suggest that in principle terrestrial bottom up driven versus remotely sensed top down carbon estimates produce similar results. However they differ in their integration of potential forest management impacts and the existing differences in the regional biomass estimation methods. An important advantage of remotely sensed driven carbon estimates is a continuous coverage while the terrestrial approach integrates density effects.

Modeling, Forest inventory, MODIS, Carbon

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3491 **Implementing different thinning types and intensities in individual tree models**

Tomé, M.* (1); Soares, P. (1); Amaral Paulo, J. (1); Barreiro, S. (1)

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Abstract: Thinning is one of the most important modules in individual tree models, with a strong impact on the prediction of future forest development. However, publications explaining how thinnings are implemented in the existing individual tree models is scarce. This presentation has two objectives: 1) to make a literature review for thinning algorithms; 2) to present and implement several thinning algorithms designed for alternative thinning types and intensities, discussing the results of its application in real stands representing different stand structures and composition. The implementation of a thinning in individual tree models implies: 1) the selection of an index/variable to express thinning intensity or residual stand density (such as removed or residual basal area, the relative spacing, or the percent crown cover), here designated by thinning index; 2) implementation of some rule to select the trees to be thinned (thinning algorithm). Thinning algorithms can be applied to the whole set of trees (in even-aged forestry) or by tree cohorts (in uneven-aged forestry) and may be spatially explicit or not. The first are based on some spatially explicit competition index. The tree with the highest value of the competition index is first thinned. After a tree is thinned, the competition indices of the trees in the neighborhood of the thinned tree are re-computed and the tree with the highest value of the competition index is again selected to be thinned. This process is repeated until the intended value of the thinning index is achieved. The second are usually based on a model that estimates the probability of a tree to be thinned. A thinning probability is estimated for each tree, the trees are randomly sorted and the decision to thin each tree is taken by comparing its thinning probability with a random number (Monte-Carlo simulation). Trees are sequentially thinned until the intended thinning index is achieved. In both cases tree quality can also be taken into account.

thinning algorithms, individual tree models

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2401 **Keep it simple: - the history of stereological measurements in forest inventory**

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Abstract: Applying the principles of stereology, information about properties with two or three dimensions (such as areas and volumes) is retrieved from samples in one or two dimensions. Thus, simple measurements can be used for estimating more complex population parameters. Stereology has many applications in life sciences, but it also has an interesting history within forestry where several important forest inventory techniques are based on stereological principles. Important examples include point and line intersect sampling for estimating areas, line intersect sampling for estimating downed log volume, Bitterlich sampling for estimating basal area, and critical height sampling for estimating growing stock volume. This presentation provides the theory for stereological measurements, shows well-known and less well-known forest inventory applications, and concludes by offering some prospects regarding the use of stereology in future forest inventories.

Bitterlich sampling, line intersect sampling

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130 - Contributions of Forest Mensuration and Modeling over 125 years

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3270 **The changing scope of national forest inventories - challenges for research and education**

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Abstract: The history of statistically planned National Forest Inventories (NFIs) is slightly younger than IUFRO, with the first NFIs implemented in the Nordic European countries starting with Norway 100 years ago. Not only have forest monitoring experts developed a comprehensive set of statistical approaches to estimation and modeling and optimized data collection procedures, but the scope of NFIs has also considerably widened. By the end of the 1970s, the term multi-purpose NFIs has been introduced and various NFIs have turned into full blown land use inventories, integrating all or part of other land uses in a country and looking at "trees" rather than "forests" only.

Currently, in particular in the context of various global challenges and in the context of the international conventions, NFIs experience an unprecedented attention. National level forest information is in high demand and the number of actors and sectors interested in NFIs and their products has dramatically increased, while the number of NFI experts does not appear to have increased in the same pace. The need for expertise manifests itself in REDD projects, for example, where data from national or sub-national forest inventories have, so-to-say, a direct monetary value (probably for the first time in the history of NFIs): higher precision of estimation less "uncertainty" may lead to higher payments.

This paper looks at methodological and strategic developments of NFIs. It analyses the corresponding consequences and challenges for research, education, outreach.

All Division 4 (Forest Assessment, Modelling and Management) Meeting

14 - Strategies and challenges for risk resilient forest management

K 8 (Konzerthaus Freiburg)

IUFRO17-3206 **Sustainable Forest Management for Bioenergy: Harnessing the Potentials in the Alps while Minimizing Risks to Ecosystem Services**

Fuss, S.* (1); Leduc, S. (2); Kraxner, F. (2); Marxen, A. (1); Serrano Leon, H. (2); Patrizio, P. (2); Mesfun, S. (2)

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Abstract: Sustainable forest management (SFM) is defined by the FAO as "[...] addresses[ing] forest degradation and deforestation while increasing direct benefits to people and the environment. At the social level, sustainable forest management contributes to livelihoods, income generation and employment. At the environmental level, it contributes to important services such as carbon sequestration and water, soil and biodiversity conservation."
Clearly, SFM is thus at the intersection of multiple demands on the forest, where fulfillment of one might risk another one. This is especially apparent in the case of conflicts between socio-economic objectives (e.g. expand operations to increase the amount of forest biomass that can be used to generate electricity and heat) and environmental strategies (e.g. aiming to conserve biodiversity). How can multiple objectives be jointly achieved while keeping ensuing risks minimal?
We demonstrate a new method for the assessment of tradeoffs between the policy goals of renewable energy expansion and conservation of ecosystem services using geospatial optimization. The new approach is illustrated for the case of bioenergy in the Alpine region, for which preliminary recommendations for forest professionals and policymakers will be formulated.

Bioenergy, Biodiversity, Alpine Space

K 8 (Konzerthaus Freiburg)

IUFRO17-978 **Challenges of risk resilient forest management in Northern Eurasia**

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Abstract: Vast scale of Northern Eurasian forests makes them a phenomenon of global meaning. Russian forests are currently not managed in a sustainable way due to decline of forest governance, lack of the infrastructure, on-going climate change and insufficient protection of forests that together leads to substantial acceleration of disturbance regimes. According to recent remote sensing estimates the area of Russian forests that are managed by state forest authorities decreased at 45 M ha in this century. Decline of dark coniferous forests is observed now in different regions, particularly in the south. Forest zone of Russia is a territory of expected dramatic climate change, up to + 7-11 °C by end of the century in some regions, with substantial increase of climate dryness. Thawing of permafrost would lead to dangerous changes of the hydrological regime over huge areas. All together generates dramatic risks for resilience of forests, and Russian forests may become a tipping element. Transition to sustainable forest management means transition to adaptive risk resilient forest management (RRFM). We consider regional specifics of climate change impacts on the country's forests; expected dynamics of the disturbance regimes; probable trajectory of future forest development; optimal ways, risks and uncertainties of transition to and implementation of RRFM. The latter requires substantial increase of political profile of forests in the country; changes of legislation and institutional structure of forest management; development of a respective system of forest inventory and monitoring; transition to a new system of forest protection. The key research questions are development of regionally distributed systems of indicators of resilience/ vulnerability of forests and stability of landscapes; development of landscape-based models of future forests and appropriate systems of management; biophysical and economic assessment of ecosystem services and trade-off between these.

risk resilient forest management, Boreal forest

K 8 (Konzerthaus Freiburg)

IUFRO17-2058 **Improvement of information support for growth and productivity of forests as a precondition for risk resilient forest management**

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Abstract: Securing sustainable forest management in a changing world is a complex task, realization of which should be based on science and appropriate practical implementation of research results. The current trends in environmental indices, especially climatic, have a significant impact on forest ecosystems. Application of traditional Eastern European approach to description of dynamics of mensurational parameters of forest stands cannot be regarded as a sufficient condition to obtain reliable estimates of their future state under climate change conditions. Development of "climatic interface" for the existing models of forests' growth and productivity is a step forward in terms of significant enhancement of possibilities of their application under the current conditions. However, with respect to the mentioned above, standardization and systematization of the existing models is a crucial precondition.
On the example of Ukrainian forestry sector, relevance and methodological provisions for improving and adapting the current information support to dynamic environmental conditions are highlighted. Attention is focused on advanced integration capabilities of a unified system of growth and productivity models for stands of main forest forming tree species. Its embedding to regional and global forestry models enables forecasting state of Ukrainian forests by middle and end of XXI century. Implementation of the proposed approach will enable adequate assessment of risks associated with forest management under climate change, contribute to decision-making support and create a platform for interdisciplinary cooperation between researchers and practitioners in Ukraine and around the world.

model forest growth productivity system Ukraine

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14 - Strategies and challenges for risk resilient forest management

K 8 (Konzerthaus Freiburg)

IUFRO17-2296 **Risk-resilient mapping of the provisioning potential of ecosystem services in a Scandinavian boreal forest using airborne laser scanning data**

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(1) University of Eastern Finland, Joensuu, Finland

Abstract: Mapping the supply, potential, demand and stock of Forest Ecosystem Services (FESs) based on remotely sensed data has become increasingly popular. Such maps may enable to spatially identify areas which differ with respect to the supply of the FESs and thus provide useful information for prioritizing the land use in forestry decision analyses. However, the maps are often based on readily available data such as land cover maps and public databases and ignoring the related uncertainties. In this study, the provisioning potential of timber, carbon storage, habitats of game bird species and recreational values (visual amenity and suitability for berry picking) was mapped in a Scandinavian forest landscape, assuming to improve the quality of the decisions based on the maps by
- modeling the provisioning potential directly based on 3D forest structure indices obtained by airborne laser scanning, and
- considering the model estimates as stochastic variables with a probability distribution corresponding to the model error.
The predictions of the provisioning potential based on the 3D indices were found to be in line with the field data. The performance of the models, however, varied considerably between the FESs, which resulted in a number of incorrect land-use decisions based on the deterministic models. The stochastic approach allowed estimating the strength of the decision with respect to the uncertainty in the predictions and identifying areas where the decisions changed depending on risk aversion. Accounting for the risk preferences of the decision maker improves the decisions and should be incorporated in the mapping of the FESs.

inventory; planning; remote sensing; LiDAR; MCDA;

K 8 (Konzerthaus Freiburg)

IUFRO17-3484 **Integrating climate change impact models for effective adaptation measures in forestry sector**

Lee, W.-K.* (1); Kim, M. (1); Yoo, S. (1); Song, C. (1); Lim, C.-H. (1)

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Abstract: In terms of mitigation and adaptation in climate change issues, forest are recognized as one of the biggest carbon sink. For the adaptation aspect, forest needs to be well managed for enhancing carbon sink capacity of forest. While forest disaster such as forest fire, land slide, insect damage, forest degradation in forest area should be prevented for the mitigation aspect. And in social area, the harvest wood product (HWP) and bio-energy should be widely used for a long time for keeping carbon in HWP and biomaterials.
Individual models such as forest growth prediction, forest cover distribution, forest carbon cycle, and forest disaster (forest fire, land slide, forest diseases) were developed considering stand and site condition, forest practice, topographical and climatic condition etc. The individual models was integrated in the way that the outputs of individual models is arranged to the 4 ecosystem services: provisioning service, regulating service, supporting service, and cultural service. And relationship and network among outputs and 4 services was identified through systems analysis and dynamics. The outputs of individual models was also arranged to social issues and needs for finding effective adaptation measures to climate change. In this way, individual models in forest sector, in which climate change is considered, could be integrated, and help decision maker to more easily understand impact of climate change on forest sector and also effectively find adaptation measures to climate change.
Lastly, we will suggest to integrate adaptation and mitigation strategies through implementing Negative Emission (NE) which encompasses Bio-energy-Carbon Capture and Storage (BECCS) technology and Harvest Wood Product (HWP) usage in social area

climate change, integrated model, forest growth

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171 - Managing Risk in the Face of Uncertain Change

KG I - Aula (Uni Freiburg)

IUFRO17-3201 **Optimal sequence of forest rotations under a declining discount rate: including thinning in a cross-european comparison**

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Abstract: Uncertainty about future rates of return on investment has led to increasing use of declining discount rate schedules. However, single discount rates and the Faustmann rotation continue to dominate managerial economics in forestry. The UK, France, Denmark and Norway have adopted declining discount schedules, while Germany retains a uniform discount rate. We explore the effect of declining schedules on optimal rotation of thinned Norway spruce. Under the French schedule, which declines from 4% to 2% after 30 years, the optimal sequence of rotations is identical to that under a uniform 2% discount rate. Under Danish and Norwegian schedules, which reach 2% in 70 and 75 years, the first rotation is shorter than subsequent ones for high productivity crops, but for lower productivity crops all rotations are equal. The uniform German discount produces constant rotation. The UK schedule, declining in small steps until 300 years, lengthens succeeding rotations for all productivities. The later rotations are the same, whenever the final discount rate is the same for two schedules: earlier discount rates do not affect rotation length. Because other European countries may adopt declining discount schedules, the Faustmann rotation may become a less common theoretical norm, for both thinned and unthinned crops.

Optimal rotation, declining discount, thinning

KG I - Aula (Uni Freiburg)

IUFRO17-975 **The self-insurance clauses puzzle, risk vs. ambiguity: an application to forest adaptation to climate change**

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Abstract: Climate change is expected to increase natural hazards occurrence. About this increase, several trends are observed, making ambiguous the forest decision making environment. In this context, many adaptation options appeared, aiming at reducing the vulnerability of forests to risks, such as forest management practices or insurance. Most policies promote the use of physical adaptation or financial one, but separately. In response, a policy based on insurance for assisting adaptation to climate change is emerging (Linnerooth-Bayer and Mechler, 2006).

Such a policy requires analyzing the link between insurance and adaptation options (as self-insurance activities) both aiming at reducing the damage in case of risk occurrence. This problem is more general and has been studied in insurance economics under risk. Indeed, Ehrlich and Becker (1972) show that insurance and self-insurance are substitutes. However, such a question had never been addressed under ambiguity.

In addition, such a policy requires dealing with the observability (or not) of the self-insurance effort. Indeed, if the effort is observable, then the insurer can account it in the insurance premium calculation.

Finally, if the insurance contract includes a self-insurance clause then a puzzle appeared. Indeed, as insurance and self-insurance are substitutable, a self-insurance clause is likely to undermine the demand for insurance.

From there, we propose to develop a theoretical model of insurance economics in which we focus on the role of the observability (or not) of the self-insurance effort and clauses. More precisely, concerning the clauses, we question: i) their level, and potentially the existence of threshold in terms of effort; and ii) the fact that they may be binding or not for the insured. Furthermore, we propose to analyze these questions under risk and under ambiguity. We also propose to test empirically our theoretical result through experimental economics.

adaptation, forest, insurance, uncertainty

KG I - Aula (Uni Freiburg)

IUFRO17-1292 **Interactive effects of climate warming and invasive pests on European forest carbon storage**

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Abstract: In view of a warming world carbon storage has become an increasingly important ecosystem service. In forests, carbon storage capacity depends, among other factors, on disturbance regimes which are, in turn, likely to be altered by different components of global change. Among these components, the human-induced spread of non-native pests may have strong, yet hardly explored effects. Here, we use a combination of species distribution and carbon cycle modelling to evaluate, first, the potential consequences that invasion by five different, non-native forest pest species (2 beetles, 1 nematode, 1 fungus and a Phytophtora from the Oomycota group) may have on European forest carbon storage; and, second, how different scenarios of climate warming may change pest invasion patterns and hence, indirectly, forest carbon storage capacity. We find that invasive pests could trigger massive reduction of carbon storage potential, though variability among species and geographical regions is pronounced. Importantly, potential negative effects of the invaders are rising under climate change either because the pests' climatically suitable ranges increase, or because these suitable ranges match the distribution of their host tree species more closely. Taken together, these results raise concern about negative feedback loops triggered by the interactive effects of climate warming and invasive pests on European forest carbon storage capacity.

pest invasions, climate change, risk assessment

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171 - Managing Risk in the Face of Uncertain Change

KG I - Aula (Uni Freiburg)

IUFRO17-1934 **Robust detection of novel invasive forest pests: New approaches to deal with uncertainty and tight budgets**

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Abstract: Uncertainty about future outcomes of biological invasions is a major hurdle in the planning of pest detection programs. We present an invasive pest detection model that incorporates the uncertainty about the entries and spread of a non-native pest and optimizes the surveillance with respect to anticipated damages from the established pest populations and the survey costs. The model makes use of the scenario-based approach and applies the Conditional Value-at-Risk concept to control the uncertainty of the costs and damages from invasion.
We demonstrate the approach by assessing the costs of detection surveys of the Asian longhorned beetle (ALB, Anoplophora glabripennis), a harmful invasive pest in the Greater Toronto Area (GTA), Ontario, Canada. We use recent data on imports of pest-associated commodities from the countries of ALB's native range and historical data on ALB spread in the GTA during past incursions to generate a set of stochastic scenarios, which characterize the uncertainty of the pest's spread and potential damage to suitable host trees in the GTA. We then use these scenarios in our optimization model to find survey allocations that enable us to detect infestations with minimum damage. Our results provide a practical approach to assess the costs of pest detection programs in the face of uncertainty about a pest's distribution and spread, the costs of survey and expected damages from an outbreak.

Asian longhorned beetle; forest pests; detection

KG I - Aula (Uni Freiburg)

IUFRO17-982 **An animated introduction to tail hunting and robust decision making**

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Abstract: Managing forest resources often requires navigating high-dimensional trade-offs under deep uncertainty. Decision support tools can help to better understand and navigate these trade-offs. However, implementing and understanding these decision support tools can be challenging. Here we present a simple introduction and an animated guide to an open-source decision support tool that implements Multi-Objective Robust Decision Making (MORDM). MORDM is a decision support framework that can help stakeholders and decision makers to (i) better understand the system dynamics, (ii) explore vulnerabilities, (iii) identify key drivers of vulnerabilities, and (iv) navigate trade-offs among objectives under deep uncertainty.

robust decision making; deep uncertainty

KG I - Aula (Uni Freiburg)

IUFRO17-1142 **Making robust thinning decisions under deeply uncertain climate change: Applying the MORDM approach.**

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Abstract: Decision makers in strategic forest management are faced with a deeply uncertain climatic future. Under "deep" uncertainty no probabilities can be attached to any future scenario which calls for decision making methods that adequately consider deep uncertainty in a non-probabilistic way.
This presentation introduces Multi-Objective Robust Decision-Making (MORDM) as a non-probabilistic decision-making approach which was originally developed for application to the water sector. Its first application to the field of forest management is presented by example of thinning decisions for an even-aged beech stand in South-West Germany. A set of alternative thinning regimes are developed through random sampling. Trade-offs of multiple management objectives are compared to the business-as-usual regime when adding climate and model parameter uncertainties to the decision process. Strategies were assessed for robustness to these uncertainties using different robustness metrics based on the concepts of "satisficing" and "regret". Finally, the individual impacts of the considered uncertainties on fulfilling performance requirements are tested which indicates the level of importance of considering climate change uncertainty for thinning decisions.

deep uncertainty, climate, thinning, robustness

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171 - Managing Risk in the Face of Uncertain Change

KG I - Aula (Uni Freiburg)

IUFRO17-3888 **Assessment of the robustness and uncertainty of climate projections applied for impact analysis and adaptation support in forestry**

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Abstract: For the assessment of impacts of, and adaptation to, the expected climate change in forestry, robust information is needed on the long-term climate tendencies. This is especially important for the Carpathian basin where the distribution of forests is already often limited by the amount of available water and thus little climatic changes may trigger tipping-point phenomena.
In order to quantify the spread and uncertainty of projections of climate change variables, simulation results of an ensemble of various SRES and RCP-based European regional climate models have been analyzed for the period 1961-2100. The models are driven by different emission and radiative forcing scenarios. The spatial resolution of the simulations was 0.22 ° * 0.22° for the SRES A1B scenario, as well as 0.44 ° * 0.44° and 0.11° * 0.11° for the RCP 4.5 and RCP 8.5 scenarios, respectively. We also used several meteorological and forestry indices to define "drought".
Our results show that (1) the sign and range of the projected change of temperature, precipitation and drought frequency are largely influenced by the applied model, the scenario and the spatial resolution of the various simulations, and that (2) unlike in other European regions, the uncertainty of the projections by the various models, defined as the range of the climate change relative to the mean change, is rather large.
Further research is needed to deal with this uncertainty, and to find appropriate methods to appropriately use of climate projections in managing climate change.

The research is supported by the ÚNKP-16-4-3 New National Excellence Program of the Ministry of Human Capacities and by the "Agroclimate-2" (VKSZ_12-1-2013-0034) joint EU-national research project.

uncertainty,climate projection, adaptation support

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61 - Decision Support Approaches in Adaptive Forest Management

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1018 **Cluster creating for harvest scheduling ARM for small-scale spatial limited forest management**

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Abstract: Forest fragmentation affects forest ecosystems by changing the composition, shape, and configuration of the patches. Forest harvesting and, in particular, the clear-cut management system which is still preferred in many European countries has a significant impact on forest fragmentation. The effect of forest harvesting on fragmentation, biodiversity, and the environment has been extensively studied and the integration of fragmentation indices in the harvest scheduling model has been already tested.
In traditional unit restriction models (URM), harvest clusters are formed a priori by the forest planner. This approach is often used in countries where the size and/or shape of harvest units are limited by the law. On the other hand there is area restriction model (ARM) modelling approach, which is based on creation of harvest clusters during the optimization process. This is done by enumerating all minimal infeasible clusters, which cannot be harvested as a whole and which are minimal. Each of these clusters is a continuous group of stands with total area exceeding the limit size and does not contain any cluster with area exceeding the limit size.
It is necessary to exclude at least one stand in such a cluster in order to obtain a feasible harvest clusters. However, it is neither possible to limit the width of clusters nor their shape by the ARM. That is the reason why the ARM couldn't be used in many countries of Central Europe until now. This contribution presents an innovative area restriction harvest scheduling model for clear-cut management system and presents a case study to demonstrate model utilization. Harvest balance and sustainability are ensured by traditional harvest flow constraints. The results indicate that harvest flow can be also achieved in minimizing fragmentation of forest ecosystems. From the analyses presented in this study, it can be concluded that integration of fragmentation into harvest scheduling is possible without high losses of harvesting.

Harvest scheduling, spatial restriction, DSS

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2863 **Creating dynamic treatment units by spatial optimization**

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Abstract: Today's approaches for forestry are in most cases based on that the forest is divided into compartments as homogeneous as possible. The compartments are described with information about e.g. volume, age and site index and it is assumed that the same management should be applied across the whole compartment. Therefore the planning of the management is also in most cases based on the compartment and the treatment unit is the same as the compartment. An alternative to the division into static compartments for planning of managements is to use dynamic treatment units. This refers to an approach where stand compartments are not considered as permanent units for data description, planning and management. The treatment units are instead created for the fulfillment of treatments after which they do not exist. The dynamic treatment units should be a function of the owner's objectives and are often based on pixel based descriptions of the forest condition. This is made possible by improvements in forest inventory that produce data with higher precision and resolution than before. The objective with this study is to present a new approach for forming dynamic treatment units based on spatial optimization. The optimization model is formulated so that pixels with similar treatments are aggregated in time and space and so that the model could be solved with mixed integer programming based on a branch and bound algorithm. In a case study a data set consisting of 10,000 pixels was used to evaluate the model with different requirements for the degree of aggregation. The results indicate that the model is effective for clustering pixels of certain properties and that the model is possible to solve within a reasonable time despite a large number of constraints and variables.

Harvest scheduling, precision forestry, heureka

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1042 **Dynamic forest planning model for private forest owners using publicly available data sources in Finland**

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Abstract: Finland has invested considerably into collecting forest inventory data from privately owned forests using Aerial Laser Scanning. This data will be freely accessible for the forest owner, and to third parties with the forest owner's consent. Currently this data is not utilised to its full potential and new tools for getting more value from this data are needed. Traditionally the standard management unit in Finland has been a forest stand. However, fixed stands might restrict the efficient use of forest resources, thus not being the best possible management units. In Finland, forest attributes have been estimated for a 16 x 16 meter grid from ALS data for all privately owned forest. It is possible to aggregate the grid cells into larger management units using various algorithms. We propose a dynamic forest planning model, which will utilize the freely accessible ALS grid data, as well as other freely available data sources and a spatial optimization model. The model will account for the forest owner's objectives, restrictions on management unit properties and the spatial structure of the forest. In addition the model will account for the temporal dimension, such as annual harvest limits. The model will also optimize the trade off between the economic profitability and operational feasibility.

Spatial optimization, Forest planning, Open Data

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61 - Decision Support Approaches in Adaptive Forest Management

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2376 **Decision on rotation period of Norway spruce in the context of climate change adaptation: Implications for Management planning in the Czech Republic**

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Abstract: Forest management and planning is influenced by a number of external, often hardly predictable factors, which define an uncertain environment in which decisions need to be taken. The risk and uncertainty increase with the length of planning horizon, and managers need to seek for options for narrowing the range of the anticipated management outputs. Climate change significantly amplifies the uncertainty of forest development, and climate change scenarios diverge in the future substantially.
Rotation period (RP) is one of the most important tool, which forest manager can use to secure sustainable and steadiness wood production, support desired age structure and respond to the needs of the market. Recent changes in tree growth dynamics, increasing rate of forest damage and environmental changes, however, have highlighted a need to reconsider the currently applied RPs.
The aim of this paper is to present the study of spruce RP adjustment according to survival probability. Following the range of survival probabilities, seven probability survival classes were created. For each of them Bayesian decision rule was applied to derive shorter RP from the production and economic point of view. To analyse influence of shorter RP on sustainability and steadiness of wood production, Czech developing decision support system (DSS) was used.
The results show that the optimal length of rotation period should be shorter than is currently used in a forest practice. The differences between currently used rotation period and newly proposed is 20 years and more. The proposed adaptation on climate change consequences does not lead directly into the new harvest scheduling model or DSS. However, it affects currently used models and it should be incorporated into the any DSSs, which deals especially with the strategic planning horizon.

DSS, survival probability, sustainability

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3803 **Decision support and knowledge transfer for improved understanding about management of protected areas across borders in Europe**

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Abstract: Decision makers in protected areas face several challenges in making a choice for the best management strategy, as external factors are often stochastic in nature and the options for adaptation are numerous. Rising demands from society regarding a sustainable provision of ecosystems services increase the complexity of such decision problems as well. So there is an urgent need to support managers of protected areas facing challenges of sustaining biodiversity and forest ecosystem services across borders considering the uncertainties of climate change and funding resources. Some studies have revealed a demand for web-based decision-support to aid natural resource managers in providing recommendations for adaptive management. In the context of the ForAdapt project a survey among managers working in protected areas was conducted to identify the key challenges in working towards natural resource management in a cross-border context. The identified challenges helped to identify the main features and functionalities for decision-support. Managers require easy access to relevant policies and laws, training resources for decision-support, grant opportunities, and an overview about available case studies, methods and tools. In consultation with the EUROPARC Federation (over 350 member parks in 37 European countries), International Union for the Conservation of Nature, and individual park managers, we developed 9 case studies of transboundary protected areas and successfully tested a participatory decision analytic approach in two of these. Natural resource managers are supported in formulating recommendations for sustaining biodiversity and forest ecosystem services across borders. In this contribution some case studies on the challenges and uncertainties regarding climate change and economic scarcity will be presented. We will discuss how the project results will be incorporated into a transboundary conservation toolkit that will be hosted by EUROPARC.

conservation management, cross boundary, knowledge

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2165 **Decision support in conflicting forest utilization: Market impact analysis of forest management and wood supply scenarios on forest product markets**

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Abstract: Contradictory interests are inherent to forest-relating decision making: How to manage domestic forests? How much forest should be protected, how much wood should be produced and what are consequences for the forest-based sector? Cross-level decision support tools to balance opposing national management options, forest utilization and wood supply are needed. Here, an enhanced version of the Global Forest Products Model (GFPM-CNC) was used the first time to compare the likely magnitude of changes in forest sector variables based on different wood supply scenarios calculated with the forest development and timber resource model (WEHAM). The technical differentiation between coniferous and non-coniferous industrial round- and sawnwood made the GFPM-CNC to a proper tool that closely assesses possible sector dynamics in dependence of forest treatment pattern and resulting timber production in Germany. For market scenario analysis, the scenario outputs of WEHAM were translated in exogenous model parameters and fed into the GFPM-CNC. The results evaluate market impact, e.g. shifts in production, consumption and trade of roundwood and wood products due to changing availability of softwood and hardwood. Uncovering these consequences of alternative long-term forest management strategies, this study supports informed decision and policy making.

Wood-products Scenarios Market-model Demand Supply

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112 - Climate change adaptation in forest management: from applied science to implementation

K9 (Konzerthaus Freiburg)

IUFRO17-1448 **Regionalization of climate change adaptation - dynamic tree species selection in the German federal state of Brandenburg**

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Abstract: Regionalization of the impact of climate change is a great challenge for forest administrations and forest enterprises in Germany. For many regions there is evidence that the vulnerability of forest ecosystems will increase due to increasing temperature, drought, and the frequency of extreme events. In a regional model for the German federal state of Brandenburg it can be shown that, under consideration of indicators such as temperature and soil water availability, areas with increased risk exist already today. By 2100 this tendency will be reinforced. The basis of the presented approach is an extrapolation of the empirical functional relationship between the forest development types and forest site characteristics into the future, taking into account scenario climate data of the federal state of Brandenburg.
In the paper we will review the results of tree monitoring and dendroecological analyses with respect to the development of tree growth and tree vitality in the German federal state of Brandenburg. Then we outline several adaptation options to increase forest resilience in Brandenburg, with special emphasis of the dynamic tree species selection process to create mixed forests. It can be shown that European beech will significantly lose distribution range in Brandenburg by the period of 2050-2100 due to the limiting impact of water shortage. The results of the model are visualized by mapping and used to establish recommendations for forest conversion.

climate change, tree species selection, beech

K9 (Konzerthaus Freiburg)

IUFRO17-3395 **Developing site-specific species recommendations in Switzerland: A pragmatic ecogram-based approach**

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(1) WSL, Swiss Federal Institute, Birmensdorf, Switzerland; (2) Forstingenieurbüro Monika Frehner, Sargans, Switzerland; (3) Abenis AG, Chur, Switzerland; (4) Kaufmann + Bader GmbH, Solothurn, Switzerland; (5) Federal Office of the Environment FOEN, Ittigen, Switzerland

Abstract: Forest managers in Switzerland select tree species for natural regeneration or planting based on ecograms, which show the location of site types on semi-quantitative gradients of base and water availability. For each site type, recommended main and secondary tree species are listed. Such ecograms exist for different regions and altitudinal vegetation belts. As extension part of a research program on forests and climate change, we quantified the climate gradients hidden in these ecograms and assessed the analogies between current and future site types under the assumption of future climates based on the A1B scenario of the 4th IPCC assessment report. The approach enables identifying overlaps and differences in species recommendations between current and future site types, under the condition that future sites are currently found within Switzerland. It was tested with forest managers and well received since it is understandable, gives plausible results, and largely builds on existing decision-making tools. In our contribution, we will critically analyze the scientific foundation and the robustness of the approach, point out its weaknesses and describe the factors contributing to its success, analyze which obstacles had to be overcome, how this was achieved, and which tasks remain to be done.

climate change; adaptation; tree species selection

K9 (Konzerthaus Freiburg)

IUFRO17-2363 **Climate change adaption in the Bavarian State Forest Enterprise: Transferring scientific knowledge into management practice**

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Abstract: The Bavarian State Forest Enterprise is a major forest holding in Central Europe that manages over 800,000 ha of state forest in Southeastern Germany. The annual cut is about 5 m m ^{3}, which generates a turnover of about 400 m Euro. The main commercial crop is Norway spruce, which produces about 70 % of timber revenues. However, Norway spruce is considered highly susceptible to the effects of climate change in many sites in Central Europe. Other important species like European beech, sessile and pedunculate oak, European ash and Scots pine have also shown significant biotic or abiotic damage recently. The climate change adaptation concept of the Bavarian State Forest Enterprise therefore aims at developing highly stable and resilient, multi-layered mixed species stands. The desired stand structure is comprised of native tree species enriched with resilient non-native species of commercial interest. According to the underlying "four species concept" all future stands will consist of at least four different tree species. The general goal of the concept is to lower the risk of an individual stand through high resilience and diversification. The presentation gives an overview of the climate change adaptation concept of a large forest enterprise and shows how scientific knowledge is transferred into management practice. We also describe how uncertainty (e.g. pertaining to future regional climate or future suitability of individual tree species) was included in our management concept. Main knowledge gaps are identified from a management perspective and ideas on future research are presented.

Bavarian State Forest, adaptation, management

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61 - Decision Support Approaches in Adaptive Forest Management

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3594 **Evaluating different strategies for lodgepole pine in Sweden - economy, distribution and potential spread**

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Abstract: Lodgepole pine (Pinus contorta) is an American tree species introduced in Sweden in the 1920s and cultivated on a large scale since the 1970s. The reason for choosing to plant lodgepole pine instead of the native Scots pine (Pinus sylvestris) is its higher productivity. When introduced, the general view was that the risk of spread was low, but lodgepole pine has been shown to both survive and reproduce outside plantations. The degree of invasiveness is uncertain in Sweden. However, if lodgepole pine would spread to areas where establishment could be a potential threat to native biodiversity, for example mires or alpine areas, it would be a problem, and to find and eradicate this unwanted spread could result in major costs for society. We have evaluated the long term consequences of four strategies for coping with the potential invasiveness of lodgepole pine: (1) No new establishment of lodgepole pine is allowed, (2) limit the total area of new establishments of lodgepole pine to a maximum of 5 % of the total area of productive forest, (3) avoid plantations around nature reserves and key habitats, and (4) aggregate the new plantations. The strategies were compared to a strategy without any restrictions regarding establishment of lodgepole pine. Each strategy was included in two different long term forest planning problems. The first one aimed for maximizing the net present value from future forest management and the second one aimed at maximizing potential harvest volume. Each problem was formulated and solved with the Heureka planning system. Preliminary results indicate that the restrictions reduces the potential maximal economic return but also the maximal potential harvest volumes from the studied landscapes which then has to be weighed against the costs of surveillance and eradication of possible unwanted spread.

Exotic species, Forest planning, Heureka, Invasive

K 2-4 (Konzerthaus Freiburg)

IUFRO17-311 **Deadwood management with robust optimisation**

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Abstract:
Forest ecosystems provide many ecosystem services for human beings as well as for the environment. Also, managed forests are seen as systems that have to fulfil many of these services. One important part is the provision of deadwood as a resource for many plant and animal species in forests. Besides the ecological preconditions and effects of deadwood are a major field of research, the economic impacts of management concepts for deadwood are not known very well so far. For example, questions like: 'How much of the financial returns is lost by applying a certain management plan?', or: 'Which strategy is the most effective way to reach the objectives of the management concept?' and the mechanisms behind that are not fully understood up to date.
We combined the risk-sensitive decision support system YAFO with a deadwood model relying on exponential decay functions to give answers for these questions. Therefore, we are able not only to investigate deadwood management plans but we can optimise the strategies of how to implement them. Main results are a severe influence of pre-set parameters like deadwood diameters or the time horizon for reaching the goals. Both aspects affect the economic returns of the forest enterprise in terms of how much of the returns that can be achieved without any deadwood objectives must be invested to provide the desired deadwood amounts. Due to losses within the pool of forest products and the changing effects of substitution, the carbon balance of the forest enterprise is influenced as well. A first conclusion is that it is important to focus not only on the goals themselves but additionally on the way of how to achieve certain deadwood goals.

deadwood, risk, optimisation, ecosystem services

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2468 **Forest restoration with a native species Paricá in Amazon: a generalizable model to support forest management**

Nobre, S.* (1); Diaz-Balteiro, L. (1); Rodriguez, L. (2); Zonete, M. (3)

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Abstract: Approximately four thousand hectares of degraded pasture land in the Brazilian State of Par á in the Amazon have been converted to a forested area since 2008. A single fast-growing native tree species was used in the process, the paric á (Schizolobium amazonicum). Paricá grows at a rate of 23 to 27 m3/ha/year and densely covers the degraded area with its canopy in approximately 2 to 3 years. Besides the improvement in terms of environmental indicators, the paric á plantation offered reasonably good income when sold for veneer logs. A generalizable model was developed to support important decisions about to be made by the forest management team. A multi-objective model was developed, using an open source algebraic optimization modelling system (Pyomo). The systems allowed the analysis of different scenarios and a comprehensive set of evaluations regarding environmental and economic objectives. Specifically, the model helped on supporting the analysis of different management regimes and production cycles, and whether managers should change species, mix them or alter tree density. It also provided price ranges that guarantee expected investment returns for the investors. Examples were provided using local yield curves, costs, market prices, and accomplished environmental gains.

restoration;multi-objective model;decision support

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61 - Decision Support Approaches in Adaptive Forest Management

K 2-4 (Konzerthaus Freiburg)

IUFRO17-33 **Current Thought on the Use of Heuristics for Adaptive Forest Management Planning**

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Abstract: Forest management planning can be a rigorous endeavour, conducted in pursuit of alternative scenarios from which decision-makers choose. Incorporation of goals and constraints concerning the management of land into a forest planning model can be challenging, particularly when these contain discrete or non-linear relationships. Exploration into the use of heuristics for supporting the forest planning process has been conducted for over thirty years as an alternative to traditional mathematical approaches. Thoughts on the use of heuristics for forest plan development have evolved, through examination of intensification and diversification search strategies and the introduction of novel methods. This presentation will describe the author's impression of the current best practices for heuristics in supporting adaptive forest management planning, and will offer suggestions for future research endeavors.

forest planning, forest management, heuristics

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101 - 125 Years of Forest Inventories - Past, Present and Future

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-361 **Forest data acquisition in Nordic countries - roadmap for the future**

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Abstract: Authors: Annika Kangas (Luke), Kari T. Korhonen (Luke), Rasmus Astrup (NIBIO), Johannes Breidenbach (NIBIO), H åkan Olsson (SLU), Mats Nilsson (SLU), Jonas Fridman (SLU), Erik Naesset (NMBU), Terje Gobakken (NMBU), Matti Maltamo (UEF)

Nordic countries have long traditions in forest inventory. In Norway, national forest inventory (NFI) was started in 1919, as the first country in the world, and Sweden and Finland started respective inventories at the beginning of 1920's. Also the traditions in forest management inventory (FMI) are long in the Nordic countries. Opportunities of remote sensing have been widely utilized: aerial photos have been used in FMI since 1950's and in NFI since 1970's (e.g. Lapland in Finland), satellite images in NFI since 1990's, laser scanning in FMI since early 2000's and photogrammetric point clouds in NFI since 2010's. Denmark, in fact, was the first country producing a nationwide laser-based product trained with NFI data. In recent years, the technology has been developing very fast. At the same time, the needs for information are constantly increasing.

In this study, we analyse the state-of-the-art both in the national level and local level management inventories in the Nordic countries. We identify the benefits and drawbacks of different RS materials and data acquisition approaches, from the point of view of different types of users or uses of the data. Based on the analysis, we identify needs for further development and emerging research questions. We also discuss the alternatives for ownership of the data and cost-sharing between different actors in the field.

forest inventory, remote sensing, benefit

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-4162 **Current Forest Inventory Initiatives to Promote Sustainable Forest Management in Brazil**

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Abstract: Brazil is well known for monitoring the loss of forests by deforestation in the Amazon region, but other government initiatives involving forest surveys are under way, using different methodologies, at different scales and to meet multiple demands for forest information. At the national level, the National Forest Inventory (NFI) is already implemented in 16 of the 27 country states. The NFI is heavily based on ground plots and, so far, approximately 2,000 tree species have been identified from 7,000 clusters of (4) plots and about 12,000 people living in rural areas have been interviewed about the local use and importance of forests. In addition, the NFI provide valuable information on the distribution of forest biomass and carbon stocks, improving estimates that are made today only by remote sensing approaches. Additional NFI sampling based components for monitoring landscapes and for short term monitoring of planted forests, based on high resolution satellite images, are also being developed. Other initiatives include permanent sampling plots networks for monitoring forest dynamics and pre-harvest forest inventories based on the census of large commercial tree species to support forest management for timber production in Amazon region. The objective of this work is to show an updated panoramic view of the main forest inventory initiatives in Brazil, highlighting how the old methods meet new technologies and tools, and how they could be better integrated to attend country's demand for forest information and development.

NFI, sustainable forest management, climate change

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1887 **New improvements in the French national forest inventory : towards the integration of forest resources assessment and ecosystem monitoring**

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Abstract: Decided in 1958 and actually launched in 1960, the French National Forest Inventory (NFI) now has nearly sixty years of experience and steady progress in reducing the costs of data collection, while improving information freshness through effective design and broadening its scope by collecting more comprehensive data on forest resources and forest ecosystems. The presentation will highlight some of these developments of general interest to tackle the new challenges of climate change, bioeconomic transition and environmental monitoring:
-The continuous design launched in 2005 in which the whole country is surveyed each year with annually updated results based on the last 5 annual samples. Since 2015 the sample includes both remeasured and new plots for better efficiency (sample size x 2) and flexibility, while retaining the advantages of fully permanent plots for change estimations. This continuous annual design with continuous partial replacement is of fundamental importance for reducing costs and extending the scope from resources assessment to ecosystem monitoring.
-The introduction in the 80's of an ecological and floristic survey which allows recently to show climate change impacts on the French forest flora and resulted in the possibility to develop (2011 - 2016) a habitat classification field protocol for forest plots. They have been all classified as habitat for the first time in 2016, opening up the possibility of a habitat monitoring survey integrated into the NFI.
-The innovative use of new technologies such as T-lidar scanning of inventory plots for a more complete assessment of tree volume and other new variables (tree architecture, stand structure, etc.) ; and the in-lab measurement by CT scanner of the wood density of the about 30000 cores per year taken from the NFI sampled trees. This opens the prospect of an inventory of forests in biomass and carbon as accurate and detailed as is today the inventory of stem volume without significant cost increase.

NFI; climate change; monitoring; new technologies

All Division 4 (Forest Assessment, Modelling and Management) Meeting

101 - 125 Years of Forest Inventories - Past, Present and Future

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-454 **Friend or Foe? Assessing the diversity-productivity relationship using forest inventory data.**

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Abstract: There is an increasing interest in the role of species diversity in ecosystem functioning and services, including productivity. Evidence is growing that mixed forests can supply many ecological, economic and socio-cultural goods and services in a similar or even better way than monocultures. The potential for interactions between different tree species are often dynamic, changing as resource availability or climatic conditions change.
In this study, we analyzed these mixture effects on species productivity along gradients of abiotic stress and site productivity. We compared the productivity of two-species mixtures with that of monocultures of the same species. The mixture effect was assessed using the additive partitioning method of Loreau and Hector (2001). This method has been successfully applied to data from large biodiversity experiments, and we wanted to test whether it can also be applied to National Forest Inventory data.
Results suggest that the productivity of mixtures changes with species assemblage and abiotic conditions and that this mixture effect is more pronounced in sites with high abiotic stress.
Finally, we discuss the pros and cons of using the partitioning method on these datasets and examine how changes in the net diversity effect are driven by changes in the contributions of single vs. multiple species to stand productivity.

diversity; National Forest Inventory; productivity

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-635 **Trees recognition based on branch extraction from UAV images**

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Abstract: Detecting trees in dense forests for inventory purposes is challenging, especially from images taken by unmanned aerial vehicles (UAV). However, some tree species such as Araucaria angustifolia provide specific characteristics, which allow its recognition. From UAV images, the branches from A. angustifolia can be easily observed, heading always uniformly towards the center of the tree. Therefore, the goal of this study was to automatically detect the branches of A. angustifolia and calculate the trajectory to which all the branches converge, registering the convergence location as the center of the tree. To achieve this goal, a python script was designed using straight line Hough transformation. Afterwards, the direction of the detected branches were calculated and the central point registered. To validate the methodology, the measured location for each tree was used. Preliminary results indicate that recognizing the branches can be a viable alternative to detect the center of the tree. Even in situations where the crowns are overlapped, it is still possible to see the direction of the branches and therefore, predict where they converge. This result proves to be a good alternative for Araucaria angustifolia trees counting in dense forests. However, further tests are required in order to optimize the results.

straight line Hough transform, tree detection

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1052 **Automatic mapping of forest stands based on three-dimensional point clouds derived from terrestrial laser-scanning**

Schwarz, M.* (1); Ritter, T. (1); Tockner, A. (1); Leisch, F. (2); Nothdurft, A. (1)

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Abstract: Intensive forest monitoring is an important tool to provide information about the timber growing stock, biodiversity, carbon sequestration and the effects of atmospheric pollution and climate change impact. Mapping of exact tree positions is a crucial task for the evaluation of forest-growth trends in a changing climate and is also required to achieve further information on structural diversity as well as to gain a deeper understanding of inter-tree competition driven by inter-tree distances and the overall tree pattern configuration.
Recent developments in sensor technology, like terrestrial laser-scanning (TLS) opened up new methods to collect high-quality three-dimensional data in the field, from which detailed 3D-point-clouds can be derived. The challenge nowadays is, to extract tree parameters from these 3D-point clouds by automatic routines.
We demonstrate novel approaches for the mapping of tree positions and the measurement of stem diameters in TLS point clouds. The detection of tree locations is based on a two-stage density-based clustering algorithm, and tree diameter measurement uses a circular clustering approach. We hypothesize that our novel method outperforms existing approaches and can be easily adopted in forest monitoring practice in conjunction with TLS.
The novel algorithms were tested in a 4.5 ha forest stand located in the Austrian pre-Alps and having high structural diversity and species richness. We show that the new algorithms provide high accuracy even under such difficult environment. The tree-position finding algorithm yields a detection rate of 95%, an omission rate of 4.5% (missed trees) and a commission rate of 5.9% (falsely detected trees). Tree diameters are measured with a mean absolute deviation of ± 2.9 cm.

TLS, wall to wall mapping, clustering algorithms

All Division 4 (Forest Assessment, Modelling and Management) Meeting

101 - 125 Years of Forest Inventories - Past, Present and Future

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1386 **A workflow for remote sensing assisted forest planning in south-west Germany**

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Abstract: Forest planning is being conducted for already a long time to ensure sustainable forest management and is usually based on classical field inventories. In the last decades, remote sensing techniques were subject of research to assist forest inventories; however, such methods are not widely applied in forestry operation, yet. We combine field data from existing forest inventories and surface models obtained from aerial images, which were collected by standard survey flights from the land survey services. Based on these we build models to produce forest attribute maps, which will support forest managers in the field to make consistent and objective decisions. In cooperation with practitioners we identify suitable remote sensing based products and develop a workflow to integrate these into stand based forest planning in the federal state of Baden-Württemberg in south-west Germany. We assess our method using independent plot and stand based reference data, and expert knowledge of forest rangers. Forest height structure and timber volume maps show most practical relevance for practitioners. Furthermore, results indicate that these forest attribute maps lie within 10% of our reference data, and are useful auxiliary information for forest managers in the field when making forest planning for the next ten years.

forest inventory aerial image canopy height model

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1422 **Remote sensing based timber volume modelling on plot level: influence of ground sampling methods**

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Abstract: Remotely sensed data in combination with ground sampling can help to create wall-to-wall maps of forest attributes utilising statistical modelling approaches. This study investigates the influence of two commonly used ground sampling methods on plot-level volume modelling using aerial imagery. The study area comprises the state-owned forest in the administrative district of Breisgau-Hochschwarzwald in south-west Germany. Here, two different methods of ground sampling are utilised on a regular basis: angle count sampling (ACS) for national forest inventory and nested circular plot sampling for enterprise forest inventory. Timber volume derived from each sampling method is combined with spectral data and a canopy height model (CHM) extracted from aerial stereo imagery. These data is used for training predictive models which are subsequently applied for creating wall-to-wall volume maps of the study area. Differences are assessed relatively between modelling results and with respect to reference data from several fully mensurated forest stands within the study area. Challenges of co-registration of ground samples and remote sensing data are also considered during assessment.

aerial images, CHM, ground sampling, volume model

All Division 4 (Forest Assessment, Modelling and Management) Meeting

119 - Quantifying disturbance effects and post-disturbance dynamics with repeatedly measured plots

K 1 (Konzerthaus Freiburg)

IUFRO17-319 **The National Forest Monitoring and Assessments (NAFORMA) process in Tanzania**

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Abstract: Abstract
Tanzania has undertaken her first ever National Forest Inventory popularly known as National Forestry Resources Monitoring and Assessment (NAFORMA). NAFORMA was conducted under the FAO-Finland (FAO-FIN) programme for support of sustainable forest management in changing climate. The selected statistical framework was double sampling for stratification, the strata being vegetation types. NAFORMA measured a total of 30,773 plots out of which 25% are permanent for long-term monitoring. The data were analyzed using newly developed allometric equations. The total growing stock is 4,062 million m3 with a mean of 46 m3/ha. The total Carbon in the living trees is 1,909 million tons with a mean of 21.6 tons/ha. Relating wood consumption estimates and increment of the growing stock shows a deficit of 19 million m3, hence necessitating increased efforts towards tree planting and sustainable forest management. The Tanzania Forest Services Agency (TFS) is committed to monitor her forests through re-measurements of the permanent sample plots established under NAFORMA. NAFORMA answers to the increasing need for forest resources data for national policy and international reporting addressing REDD+ and climate change as a whole. The work conducted in Tanzania has been instrumental for the development of FAO-FIN methodologies and tools based on cost free open source software.

forest inventory, sampling, volume, carbon

K 1 (Konzerthaus Freiburg)

IUFRO17-822 **Forest Monitoring and Human Impact Assessment on Forest Resources in Democratic Republic of East Timor**

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Abstract: The first National Forest Inventory (NFI) made in the Democratic Republic of East Timor began in the course of the Second Rural Developing Program, having been inventoried within the framework of that program two districts of the country (Bobonaro and Covalima districts, 2008-2009). The NFI information encompasses the traditional forest inventory variables with major focus on forest and other woodland areas extent and condition, species diversity and growing stock. Results of the NFI for the inventoried districts are summarized in the current communication. The results highlight a negative impact of ongoing human activities in both forests extent and condition, with the degradation of forest conditions being mainly driven by illegal logging, demand for fuelwood and shifting cultivation.
Approaching a decade after the beginning of the NFI, the authors bring to the discussion the implementation of the NFI along the country and at the district level. The sampling procedure is revisited to analyse the feasibility of reducing the costs with field work without compromising the representativeness of the estimates. Major focus is on the evaluation of growing stock. The use of allometric models for the volume estimation is also discussed. Suggestions for improving future forest resources assessments are provided.

inventory, growing stock, shifting cultivation

K 1 (Konzerthaus Freiburg)

IUFRO17-2061 **How do long-term increases in background mortality rates and disturbance each affect forest biomass?**

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Abstract: Recent increases in tree mortality have been documented in a number of regions, but it remains unclear whether these changes reflect elevated background mortality or more frequent disturbance. I estimated variation in tree mortality, and its consequences for aboveground biomass dynamics, across forest inventory plots in different regions of North America. In the eastern USA, disturbances that produced at least a four-fold increase in mortality over a five-year interval were observed in 1-5% of plots in different regions. Incorporating stochastic variation in mortality (based on mixed models fitted to the plot data) into a forest dynamics simulator showed that a long-term increase in mortality would support greater regional aboveground biomass when expressed through disturbance compared with background mortality, particularly for early-successional species. This difference could be important in regions where mortality has increased in recent years. In the Canadian province of Alberta for example, an increasing fraction of plots have experienced mortality that is at least four times greater than the long-term average, but these changes have occurred in concert with a higher median plot mortality rate. Long-term increases in mortality may cause greater reductions in forest biomass if stand-level mortality increases are chronic rather than episodic in nature.

disturbance, forest dynamics model, tree mortality

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119 - Quantifying disturbance effects and post-disturbance dynamics with repeatedly measured plots

K 1 (Konzerthaus Freiburg)

IUFRO17-2062 **Structure and dynamics of woody debris as indicators of forest disturbance**

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Abstract: The origin, amount and structure of woody debris are important characteristics from multiple perspectives. They are not only ecological indicators of forest naturalness and biodiversity, but can also provide us with the information about past natural and human-induced disturbances. In the presented work we analyse a large empirical dataset originating from the national inventories of the Czech and Slovak Republics consisting of more than 15,000 repeatedly measured sample plots. We examine the state, amount and distribution of woody debris components in specific site and ecological units. The data are further stratified with regard to the applied forest management and natural disturbances. This allows us to identify the differences in the descriptive woody debris characteristics and in the short-term dynamics of woody debris quantified using the repeated inventory measurements at different spatial levels. The results show that site and ecological characteristics significantly influence the state, amount and origin of woody debris, which can in turn be used as valuable indicators of past forest disturbances.

forest inventory,coarse debris, fine debris, stump

K 1 (Konzerthaus Freiburg)

IUFRO17-1063 **Evaluation of carbon loss derived from wind disturbance in planted forests in Japan using repeated measurement data of permanent plots**

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Abstract: We examined carbon loss in planted forests in Japan caused by windthrow, using repeated measurement data of permanent plots. We also simulated carbon dynamics assuming no wind disturbance using a carbon-balance-based stand-growth model for comparing carbon dynamics with and without wind disturbance. Both direct and indirect forest carbon loss induced by wind disturbance considerably affected forest carbon dynamics. Trees felled by wind will decompose and the stored carbon will subsequently be released to the atmosphere as direct forest carbon loss. In the absence of wind disturbance, damaged trees will continue to grow and absorb carbon from the atmosphere. This expected carbon absorption, which would have been lost owing to wind disturbance, can be regarded as indirect carbon loss. We evaluated both direct and indirect carbon loss in Japanese cedar-, Japanese cypress-, and Japanese larch-planted stands where long-term permanent plots had been established. During some decades of observation, wind disturbance occurred on several occasions and data measured during these events were utilized for the evaluation. In Japan, large areas of unmanaged planted forest exist where wind disturbance risks are increasing, and our findings indicate that careful management of these forests is needed to prevent carbon loss caused by wind disturbance.

carbon loss, carbon dynamics, growth model

K 1 (Konzerthaus Freiburg)

IUFRO17-4170 **Vegetation Pattern 8 Years After the Eruption of Chaiten Volcano, Chile**

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(1) Department of Silviculture and Nature Conservation, University of Chile, Santiago, Chile

Abstract: Active volcanoes are frequent in Chile. Volcanic eruptions are important disturbance processes in Chilean forests, and also around the world. Different disturbance types were characterized after the 2008 eruption of Chaitén Volcano: a blast-zone (tree removal, toppled tree, scorch), airfall tephra, pyroclastic flow and fluvial deposition. The most frequent forest types disturbed by the eruption where Nothofagus betuloides, Evergreen and Nothofagus antarctica. The blast zone area covered around 4 km2. The aim of this study is explore early vegetation succession on the blast zone at Chaitén Volcano. In 2012 and in 2016 (after four and eight years after eruption), the vegetation occurring in the blast zone was surveyed to document changes since 2008. Floor vegetation was sampled in a network of 50 permanent plots (16 m2) in 2012. However, only 40 were reached in 2016, because of changes in the topography. Four years after eruption 34 vascular plant species were found. The most diverse life forms were herbaceous perennials (32.4%), shrubs (23,5%) and trees (20,5%). Six community types were classified which overlap slightly. However, eight years after eruption, preliminary results showed that 65 vascular plant species were identified, and the most diverse forms were similar to those founds in 2012: herbaceous perennials (41.3%), shrubs (23.8%) and trees (11.1%). Repeated measures plots allow us to quantify the vegetation dynamic after the eruption of Chaitén Volcano and to recognize if environmental factors may produce differential successional trajectories or more stable communities along time.

volcanic disturbance, forest succession

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K 1 (Konzerthaus Freiburg)

IUFRO17-657 **Post-disturbance regeneration dynamics in the mountain spruce forests in Central Europe - lessons from 20 years of natural development**

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Abstract: Large, severe disturbances drive many forest ecosystems over the long term, but pose management uncertainties when human experience with them is limited. Following a series of large, severe outbreaks of spruce bark beetles (Ips typographus) in Central Europe we evaluated regeneration dynamics in Norway spruce (Picea abies) forests across the Bohemian Forest Ecosystem (spanning Germany and the Czech Republic). We tracked 20 years of post-outbreak regeneration dynamics of all tree species and evaluated initial variations in successional pathway and structure. Median tree regeneration density increased from ~400 trees ha-1 at the time of outbreak to ~2,000 trees ha-1 within a decade. These increases were driven by spruce, which primarily recruited from advance regeneration, gradually occupying greater height classes. Only Common rowan (Sorbus aucuparia) increased in relative proportion, for a brief (<3-year) period before declining again. In addition, spatial pattern in trees showed high resilience to stand-replacing disturbance. After a self-thinning of recruits tightly clustered around parental trees, their spatial pattern will mirror the pattern of trees that formed the stand before the disturbance. This "memory" of tree spatial patterns is an important structural legacy and should be viewed as a fundamental property of these forests. Our results showed that, contrary to common expectations, spruce beetle outbreaks in Central Europe effectively promoted Norway spruce in the long-term. Outbreak-affected forests are naturally self-replacing even after severe canopy mortality and 20 years after the outbreak the regeneration density is high enough to secure all the ecosystem functions of those forests. Thus, natural regeneration may be considered among the most effective ways to meet reforestation objectives in beetle-killed forests.

disturbance, forest, bark beetle, regeneration

K 1 (Konzerthaus Freiburg)

IUFRO17-1526 **Post-fire fine fuel dynamics in California's forests**

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Abstract: Forest wildfires result in immediate carbon losses and in changes in post-fire carbon dynamics. We examined the dynamics of duff, litter, and fine woody detritus (FWD) carbon during the first 6 years following forest wildfires in California as a function of crown fire severity, time since fire, pre-fire woody carbon, and forest type group, using repeated measurements of 129 U.S. national forest inventory plots. Stands that burned with low and moderate severity contained similar amounts of FWD carbon after fire (0.75 Mg/ha and 0.63 Mg/ha, respectively), while little FWD carbon was left in severely burned stands (0.16 Mg/ha). In the years following the fire, FWD carbon increased significantly in stands of all three severity classes, with similar rates in low and moderate severities (17.3% and 15.3 % per year, respectively), and a higher annual rate of change in stands that burned with high severity (45.4% per year). Litter carbon increased significantly in moderate (13.3% per year) and high (28.2% per year) severity stands, with no observed change in low severity stands ($p=0.21$). There was no evidence of net change in duff carbon in the first 6 years after the fire irrespective of crown fire severity ($p > 0.25$). While many studies focus on the dynamics of large woody carbon pools (e.g., standing live and dead wood, coarse woody detritus), this study focuses on the post-fire carbon dynamics of the fine fuels that typically have fairly high combustion rates and turnover.

carbon dynamics;disturbance;longitudinal analysis

All Division 4 (Forest Assessment, Modelling and Management) Meeting

Forest information for bioeconomy outlooks – a joint session of the European National Forest Inventory

KG I - 1010 (Uni Freiburg)

IUFRO17-1061 **Potential of remote sensing based forest attribute modelling for harmonising NFIs across Europe**

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Abstract: Providing harmonised estimates of NFI data at the European scale is challenging, NFI protocols differing from country to country. Because harmonising NFIs protocols is not achievable, it is necessary to both develop generic and flexible estimation procedures accounting for NFIs specificities, and to harmonise target attributes at NFI plot level. Due to their high spatial coverage and acquisition frequencies, aerial imagery could be used as a powerful source of information to both support multisource forest inventories and wall-to-wall forest attribute mapping. In the framework of the Horizon 2020 DIABOLO project, we focused on the stereoscopic capabilities of aerial photographs to generate 3D models of forest canopies and extract 3D parameters correlated with field measurements at the plot level. In this research, the selected parameters were used to assess timber volume in two forested areas localised in France and in Germany. The achieved accuracies indicated the level and transferability of the variables for large scale mapping or multisource inventory and their potential for harmonising NFI data in Europe.

aerial images, forest inventory, forest attributes

KG I - 1010 (Uni Freiburg)

IUFRO17-3090 **Matching plot-level tree maps with 3D remote sensing data towards the development of small area estimations**

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Abstract: 3D data from airborne laser scanning and photogrammetry are valuable sources of information for assessing and estimating forest parameters, and have been widely used with field inventory data for both mapping forest parameters and supporting multisource inventories. This combination supposes the data to be accurately registered. While 3D remote sensing data might provide metric accuracy, field plots positioning remains largely constrained by the precision of GPS measurements under forest canopies.

Different approaches have been proposed to solve this issue. These mostly consisted in matching algorithms aiming to spatially adjust height information from field inventory with remote sensing-based models of canopy height (CHM). State-of-the-art approaches rely on either point-to-surface or point-to-point matching algorithms. The former aimed to match the field data with the CHM using a correlation or an error minimization approach. The later one optimized the field plot position by matching tree positions with local maxima (LM) extracted from the CHM. Both approaches show limitations. Point-to-surface approaches did not make any hypothesis on the tree position on the CHM and could lead to inappropriate matches. Conversely, point-to-point ones make strong assumption on the spatial distribution of trees. However, they are sensitive to the quality of the LM.

We propose an algorithm taking advantage of both approaches. The method is based on a point to surface matching algorithm constraints by LM. In our matching design, the LM are only used to constrain the matching positions tested. Practically, a search algorithm moved the field tree map in a given neighborhood, ensuring that the highest tree measure on the field is located over a LM. The most likely position is defined based on a criterion using both the correlation and the height error. The algorithm was tested using French NFI data, and validated using terrestrial lidar data collected for a sample of plots.

Forest inventory, Lidar, Co-registration algorithm

KG I - 1010 (Uni Freiburg)

IUFRO17-2776 **Improved ways for assessing and monitoring the connectivity of forest habitats: how much we gain from high-resolution spatial data?**

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Abstract: Managing connectivity is a key part of the efforts for forest biodiversity conservation and green infrastructure reinforcement in Europe. In recent years, several studies have modelled connectivity using datasets available at the European level. There is, however, a lack of understanding on how models based on continental datasets perform compared to those conducted at more detailed spatial scales, such as those typically considered for regional forest management planning, and on how these models can provide guidance and insights into actual forest landscape management measures aimed to reinforce the functionality of green infrastructure. Here we present a set of studies that compare the results of habitat suitability and connectivity models developed at two levels of spatial resolution: a coarse-resolution land cover data (CORINE) available for all Europe and more detailed land use maps at national or subnational level. We characterize the differences in habitat suitability and connectivity estimates, and discuss the related implications for forest management planning, and for the restoration of the intermediate landscapes in between forested habitats.

forest green infrastructure, connectivity

All Division 4 (Forest Assessment, Modelling and Management) Meeting

Forest information for bioeconomy outlooks – a joint session of the European National Forest Inventory

KG I - 1010 (Uni Freiburg)

IUFRO17-4063 **Future 3D remote sensing data support for National Forest Inventories**

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Abstract: Three dimensional (3D) remote sensing data might be very effective for improving estimates from National Forest Inventories (NFI), as well as for optimising NFI plot locations and for the production of accurate wall-to-wall forest maps, using NFI plot data as ground reference. Research in the European Union FP7 project Advanced SAR has shown that the correlation with important forest variables such as growing stock is highest for airborne laser scanning data, followed by, in decreasing order: 3D point clouds from very high resolution satellites; 3D point clouds from aerial photos; interferometric SAR data from the TandDEM-X constellation, and stereo processed TanDEM-X data. There is also a large future potential for combining satellite-borne lidar data with NFI field data. The bottleneck for operational use of all these types of data is, however, often the secured operational supply of data, which needs to be achieved through political processes on national and international level. In this presentation, both key results from estimating forest stand characteristics with different 3D techniques, as well as the results from a questionnaire to the European National Forest Inventories about the expected future demand for these types of 3D remote sensing data, will be communicated.

Remote sensing, lidar, 3D point clouds, InSAR, NFI

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IUFRO17-3321 **Harmonisation of Stem Volume Estimates in Europe**

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Abstract: Growing stock estimates of European NFIs are usually not comparable across country borders. Differences occur mainly in the applied dbh-thresholds and in the target volumes of volume functions which in- or exclude the tree parts stump, stem top, or branches in the predictions at sample tree level.
For solving the lack of comparability a definition-based harmonisation approach is applied that identifies the deviations of country-level definitions from commonly agreed reference definitions, and adjusts the deviations by bridging functions. 22 European NFIs are involved in this harmonisation work within DIABOLO. Five different reference volumes were defined based on included tree parts. The reference definitions also specify a dbh-threshold of 0.0 cm and refer to living and standing trees. A central harmonisation feature is that the existing sets of volume models of NFIs are maintained. Depending on the situation in NFIs regarding available data sources and implemented volume models different bridging functions are applied to obtain tree volumes according to the reference definitions. Examples include volume models for small trees, the adaptation of taper curves, the re-parameterisation of volume functions, or complementary volume models for the individual tree parts stump, stem top, and branches. The reference volumes at sample tree level are up-scaled to country-level growing stock estimates to evaluate the effects of harmonisation measures.
First results indicate that the volume proportions represented by trees below the dbh-threshold, and by stumps, stem tops and branches depends on forest characteristics like diameter distribution, species composition, and felling practices. The growing stock results according to the five reference definitions provides the opportunity for NFIs to flexibly respond to different information needs at country and international level which are still increasing and diversifying.

NFI, Harmonisation, Stem volume, Growing stock

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IUFRO17-3182 **Pan-European harmonised biomass models for the most frequent forest species**

Bouriaud, O.* (1); Casella, E. (2); Freudenschuss, A. (3); Gschwantner, T. (3); Hervé, J.-C. (4); Kaendler, G. (5); Klatt, S. (6); Longuetaud, F. (7); Marin, G. (8); Kucera, M. (9); Nord-Larsen, T. (10); Santenoise, P. (7); Riedel, T. (6); Saint-André, L. (7); Vonderach, C. (5)

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Abstract: Estimating forest biomass at large scale and its partitioning into components is a pressing issue, stressed (i) by international reporting obligations, (ii) by new demands for bioenergy and bio-products and (iii) the need to optimize forest management for biomass production and carbon uptake. In Europe, National Forest Inventories make available a comprehensive and unbiased sampling of single trees in forests, which, combined with allometric equations, are used to provide estimates of biomass stocks at a national level. However, these equations are generally developed at regional or national level and exhibit a great variety in their form, and the detail they provide between countries. Harmonised, unique sets of equations of volume and biomass, including their partition into components, would offer the possibility of harmonised Pan-European estimations of current forest biomass stocks and their changes over time.
For this study, we have compiled a meta-database on stem volume, stem, crown and/or total tree biomass values from our DIABOLO partner consortium (8 partners) for more than 4900 trees (20 Spp.). Gaps in definitions and sampling methods have led to differences in available data but the development of bridging functions compensates them. Combining different fitting methods including raw data and pseudo-data generation, new sets of volume and biomass equations are been built.
Initial results demonstrated a good consistency of trees allometric relationships despite the north-south and west-east spatial gradients, and validated the hypothesis that a single set of equations could provide adequate estimates at Pan-European scale for each tree species. By merging the data from such a large range of growing conditions, the database reveals trends otherwise hard to detect from smaller, e.g. national, datasets. These models will enable the mapping and partitioning of biomass over Europe for the major European tree species.

Allometry, Biomass, Forest Inventory, C accounting

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IUFRO17-1955 **Harmonising, improving and using social and recreational data in National Forest Inventories across Europe**

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Abstract: This presentation reports on a pan-European survey of the use of social and other recreational data in National Forest Inventories (NFIs), carried out as part of the EU-funded project DIABOLO. First, we obtained descriptions of the specific social/recreational data used within each country and how these are assessed. Variables were separated into 5 categories: 1) Recreational amenities and facilities, 2) Recreational and non-recreational use, 3) Abuse, 4) Cultural sites and features, and 5) Other social/recreational variables. Secondly, we investigated the inclusion of additional data of relevance to recreational use, e.g. land ownership and distance to roads and settlements. Thirdly, we asked about the NFI sampling methodology used in each country, approaches to analysis and reporting, and sought to understand the story of how social/recreational data were included in each national NFI. The findings varied greatly between countries. We highlight the situation UK and Denmark, where social/recreational data is well developed, outlining how it might be used to inform forestry and nature-based tourism policy. To conclude, we propose a specific set of social/recreational data and indicators, which could be introduced in other national NFIs, and form the basis of a European synthesis of the recreational use of forests.

social data, recreation, national forest inventory

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IUFRO17-3412 **How can NFIs meet the growing demand for forest information at European scale? - Lessons learned from the last decade**

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Abstract: The information demands from forest related policies are constantly evolving, introducing new and challenging components to the information system. Historically, the NFIs have been developed to meet national information needs and therefore they use national definitions. During the last decade a special concept for harmonisation has been developed from the European National Forest Inventory Network (ENFIN) to transform information from national levels to a standardised European level.
During two COST Actions (E43 and USEWOOD) so called reference definitions were established. Based on international definitions they form a commonly agreed base for the harmonisation work. The NFIs have the option to bridge the gaps between national and reference definitions and/or to use the reference definitions for future assessments. Especially for newly developed NFIs, the second option is straight forward. In the course of two framework contracts between the Joint Research Centre and ENFIN, first applications of the harmonised information were tested and applied for many European countries. Especially tree species occurrence, basal area, and biomass estimates were derived in a harmonised way. These kinds of international estimation procedures have to follow strict rules concerning the data policy. Different approaches were applied: i) A bottom up methodology where all data computations were done at the national scale. ii) The use of an intermediate central data platform which was filled with data by the NFIs and used for all analyses afterwards. Both systems have their pros and cons. Therefore, a flexible system which is open for both possibilities is essential for future harmonisation projects.

Harmonisation, Definitions, European Estimates

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IUFRO17-3777 **Monitoring forest disturbances and substantial changes in Europe as a permanent service based on S2 & Landsat comprising rapid assessment and annual maps**

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Abstract: M. Dees1, H. Gallaun2, N. Koutsias3, E. Bretton4, O. Chaskovskyy5, D. Borota6, D., P. Datta1, D. Pantic6, M. Medarevic6, D. Karadziz6, S. Obradovic6, B. Sljukic6, M. Schardt2

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Abstract
Disturbances caused by storms, bark beetles and fires have increased in Europe's forests throughout the twentieth century and are likely to increase further, resulting in a wide range of negative impacts on the quality of life, economy and the environment. As a result, there is an urgent need to provide information on forest health and vitality, including forest disturbances (i.e. forest fires, storm damage, drought stress, insect and disease outbreaks), which must be readily available to end-users, i.e. forest policy, forest administration and forest management planning entities.
At the same time the Sentinel 2 A/B and Landsat data from 2017/2018 onwards usher in a new era forest monitoring of forests.
Based on Sentinel 2 A/B and Landsat data within the H2020 project DIABOLO (diabolo-project.eu) a system is developed and tested both facilitating both a rapid assessment (near real time) as well as annual maps designed for a pan-European coverage.
Results from the service development covering mapping examples from Europe will be presented and discussed.

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IUFRO17-629 **Assessing leaf-on and leaf-off airborne laser scanning data to derive information surrounding structural diversity in UK forests**

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Abstract: Species diversity and habitat quality can be closely linked to forest structural diversity metrics derived from airborne laser scanning (ALS) data. However, the canopy conditions ALS datasets are collected under can influence the accuracy of any biophysical parameters derived. This is because seasonal leaf loss can affect the penetrability of the laser through the canopy.
In this study both leaf-on and -off small footprint ALS datasets provide diversity variables that correlate well with the field-based reference observations. Leaf-off variables provide stronger relationships than leaf-on for crown shape diversity. On the other hand, kurtosis of tree height diversity and DBH diversity correlates better with field data under leaf-on conditions (R^2=0.53 vs. 0.52 for tree height diversity and 0.54 vs. 0.46 for DBH diversity). Despite the apparent greater predictive abilities offered by leaf-off ALS data in this study, the variables show more collinearity and so are limited by what can be included in the same regression model.
Leaf-on and leaf-off multivariate linear models for estimating tree height diversity both account for 65% of the observed variance. However, when incorporating variables from both datasets, this increases to 77%. It is likely the combination helps to better explain variability in the field-based reference data. Subsequent models for estimating DBH diversity and crown shape diversity constructed from leaf-off diversity metrics account for 3%-21% more of the observed variance than models utilising leaf-on diversity variables. The results suggest strongly that ALS derived tree height diversity models can be used to differentiate between single and multiple storey forest structure. Furthermore, ALS derived crown shape diversity models are more susceptible to the influence of canopy conditions.

ALS, Canopy Conditions, Forest Structure

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IUFRO17-647 **Design-based kriging maps of forest tree species and size diversity**

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Abstract: Until now, methods routinely adopted to reconstruct population maps lie mostly in the realm of model-dependent inference. Under model-dependent approaches, the probability distribution of any sample statistic is determined from the uncertainty entailed by the super-population which has been supposed to generate the population values, conditional on the sampled points. In model-dependent approach, the most common techniques are the kriging predictors. Throughout the years, kriging has become a standard procedure for the interpolation of spatially distributed data in several disciplines (geology, climatology, meteorology, etc.). Widely adopted techniques of this kind are cokriging, locally weighted regression and k-nearest neighbour methods. In this paper we attempt map reconstruction in a design-based framework, i.e. population values are viewed as fixed constants and the probability distribution of any sample statistic is determined from the uncertainty entailed by the probabilistic sampling scheme adopted to select sites. Values at single unsampled sites are estimated by means of a spatial interpolation, adopting a weighted function of the sample data. Weights decrease with the distance of the sample sites from the site under estimation. The design-based asymptotic properties of the interpolator are considered as the number of sampled sites increased. Conditions ensuring design-based asymptotic unbiasedness and consistency are derived. These conditions essentially require the existence of a Riemann integrable surface onto the study area and the use of spatially balanced sampling designs to select sites. A very portable mean squared error estimator is adopted. The results of a simulation study are reported to confirm the theoretical results. An application of the method for estimating the map of ecological diversity and basal area in the forest of Mount Cimino (Central Italy) is considered as a case study.

forest mapping, forest inventory, uncertainty

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IUFRO17-1808 **Lorenz curves of Tree Size and Growth Inequality: Tree Competitive Dominance and Forest Structure assessed through LiDAR and Spectral Dominance**

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Abstract: The Lorenz curve is a method developed in economics over a century ago, and widely employed for analysing inequality of the wealth distribution in societies. It has also been recently proven useful for developing applications in ecology and biodiversity, showing relations of inequality in either sizes of individuals in a population (Heywood, 1986; Damgaard & Weiner, 2000) or abundances in species assemblages (Wittebolle et al., 2009). In forest science, the Lorenz curve has been sparsely employed in different applications to e.g. describing forest structural homogeneity (de Camino, 1976; Valbuena et al., 2012) or growth dominance (Binkley 2004). A common theoretical framework is however lacking, which would unite the methods conceptually, linking them those already existing such as size-biased distribution theory (Gove & Patil, 1998) or applications to analyzing size-asymmetric competition (Pretzsch & Biber, 2010). In this communication we approach the concept of Lorenz ordering applied to forest science in the boarder sense, thinking of a general theory of Lorenz ordering as a natural continuation of others already existing for describing diameter distributions, species composition or growth partitioning among trees of different sizes. We will summarize research work on developing adaptions of Lorenz ordering to the study of forest structure and competitive tree dominance, as well as its assessment through remote sensing technologies, both active (lidar) or passive (multispectral).

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competition; dominance; inequality; remote sensing

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IUFRO17-1088 **European Mixed forests in Europe: towards an estimation**

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Abstract: Reducing the share of single-species stands by promoting tree species mixtures is recognized as a way to support large variety of forest biodiversity. The Forest Europe indicator # 4.1 "Tree species composition" is targeted to monitor progress made by sustainable forest management in Europe in establishing tree species mixtures. According to the latest assessment (2010), only one third of European forests is dominated by a single tree species, while about 70% contains two or more species, each accounting for more than 5% of total stand basal area. Is such a figure a reliable estimation of the proportion of single vs mixed forest in Europe?
To address this question, in the framework of the COST Action "European mixed forests - EUMIXFOR" an estimation exercise was performed to assess the current share of mixed vs. pure forest stands in a sample of 20 countries, based on standardized basal area measurements gathered in the framework of the EU project Biosoil project and ICP Forest activities on a network of about 2900 sampling units.
Sample proportion estimation was applied to derive: i) the forest area covered by single species vs mixed forest stands, using increasing thresholds of tree species basal area out of total basal area of the plot (BA: 5%, 15%, 20%); ii) the share of single-vs mixed forest stands by ecologically distinct groups of forest communities, as categorized by the 14 categories of the European Forest Types classification.
Findings from this exercise highlight that the most widespread condition of mixed forest stands is represented by two species coexisting, with a proportion out of total forest area ranging from of 31-34% (BA threshold 5%, E%=2.4%) to 27-30% (BA threshold 20%, E% = 2.7%). Species mixtures are found across all European Forest Types, but are naturally more widespread (share up to 50%) in some specific types (Thermophilous deciduous and Mesophytic deciduous forests).

key words: single vs mixed forests, estimation

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IUFRO17-2983 **Pan-European forest biodiversity monitoring through the ICP-level I network. First results from the BIOSOIL-BIODIVERSITY project**

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Abstract: The Sustainable Development Goal 15 of the 2030 Agenda for Sustainable Development aims at "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss". The EU Biodiversity Strategy contributes to the Goal 15 of the SDGs as its objective is to halt the loss of biodiversity and ecosystem services in Europe.
Forest ecosystems are some of the most biodiverse habitats. For this reason, it is very important to specifically monitor temporal and spatial trends of biodiversity in order to find those areas more affected by biodiversity loss and to guide land management and conservation actions. A vast monitoring program covering the comprehensive concept of biodiversity would be impossible or at least financially prohibitive. Thus a successful and statistically rigorous monitoring program able to track changes over time and space must be based on indicators. Even if scientists have investigated a large number of compositional and structural biodiversity indicators, a clear consensus on the definition of the best set of indicators was not yet reached.
In the framework of the two-years long BioSoil Forest Biodiversity Demonstration Project a large set of field data and information was acquired. The database includes data and information on living trees, deadwood and a complete vegetation survey. On the basis of raw data we calculated several forest biodiversity indicators and analysed their inter-relationships, and their variation in different forest types and environmental conditions. The analysis contributes to advance our knowledge towards the selection of an adequate set of forest biodiversity indicators to support the characterization of European Forest Types.
The results provide a fundamental and consistent support for the future implementation of multi-scale assessments of forest biodiversity.

ICP, biodiversity, forest monitoring

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IUFRO17-1084 **Using the k-Nearest Neighbors technique for multivariate forest structural diversity estimation**

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Abstract: Forest structural diversity is recognized as a fundamental component of forest biodiversity and is characterized by a larger number of plant and animal communities sharing a common multidimensional space of habitats and niches, thereby making greater use of available resources. Because forest structural diversity includes multiple components, rigorous assessment of structural diversity requires simultaneous assessment of these components via a multivariate approach to prediction. The k-Nearest Neighbors (k-NN) technique is well-suited for such problems because not only is it multivariate but it is also non-parametric which accommodates the non-Gaussian distributions of the diversity component variables. Optimization of the k-NN technique requires selection of an optimal subset of the available predictor variables, a distance metric for selecting neighbors, a neighbor weighting scheme, and the number of neighbors. For a study area in north central Minnesota in the USA, two optimization criteria were considered: (i) maximization of the sum or pseudo-R2 values for the structural diversity components, and (ii) minimization of hyper-volume of the joint confidence region. The criteria were compared with respect to each other and to inferences in the form of a confidence interval for an index that combines the components.

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IUFRO17-998 **Logical consistency and accuracy using single-step versus multi-step processes to monitor forest biodiversity**

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Abstract: Biodiversity has been defined simply as the "variety of life" and is linked to ecosystem and environmental health. To practice ecosystem management, forest managers must be able to evaluate past management practices and to choose future forest management activities that sustain biodiversity. However, many indicators of biodiversity have been proposed for forest land areas and most of these are difficult to monitor over time, especially for large forest land areas. In this paper, we propose a vector of stand-level measures as biodiversity indicators, namely tree species richness, tree species evenness, and structural diversity that have collectively been shown to be related to animal diversity (i.e., via habitat diversity) and to overall plant diversity. We use multi-source data, here digital color infrared aerial photographs, LiDAR data, ground-plot data, and other measures from existing map layers (e.g., topographic measures) to map this vector of biodiversity indicators using a single-step multivariate approach compared to a multi-step recursive approach. We then discuss: 1) Are there trade-offs in accuracy for each measure versus logical consistency among measures and does this vary for these two approaches? 2) What are the spatial and temporal scaling issues associated with this vector of measures? and finally, 3) What recommendations can be made for monitoring forest biodiversity based on this research?

biodiversity indicators, consistency vs accuracy

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K 8 (Konzerthaus Freiburg)

IUFRO17-962 **Estimation of stand biomass and other structural variables with LiDAR and error assessment at different sample sizes.**

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Abstract: An improvement in the quality of the biomass and other forest attributes estimations may be achieved when auxiliary data coming from a LiDAR mission are included.

Materials and methods used:
This analysis is carried out on the Peña del Águila, mountainside, located in Fuenfria's Valley (Cercedilla, Madrid). To this day, the LiDAR flight has been used in 2011 and in two field inventories; one of them was made in 2013/2014, covering 60 sampling plots, and the other one made in 2015, covering 80 sampling plots. Multiple regression models were designed for the basal area, density, quadratic mean diameter, dominant height, biomass and volume variables. The errors committed in estimating these forest attributes were analyzed from models and by using random sampling methods, reducing the number of sampled plots.

Main results:
It has been found that the addition of LiDAR's information significantly reduces the forest inventory errors.

Furthermore, stand, pixel and whole area level estimates were carried out using sampling design and model based techniques and the errors committed were compared. The first technique included the simple random sampling and the model assisted estimation; the second one approached Small Area Estimation (SAE) techniques. Moreover, the model based estimation allowed to develop a pixel and stand level error mapping.

Finally, outcomes showed that EBLUP estimators (Empirical Best Linear Unbiased Predictor) bring out more accurate estimates tan those coming from sampling design based techniques, in population subunits (stands).

EBLUP, LiDAR, Small Area Estimation, uncertainty

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K 5-7 (Konzerthaus Freiburg)

IUFRO17-31 **Measuring and ranking FM scenarios using particular multivariate and multi-criteria methods**

Hodges, D. G.* (1); Zadnik-Stirn, L. (2); Krc, J. (2); Leban, V. (2); Pezdevsek Malovrh, S. (2)

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Abstract: A primary contribution of forest economics over the past 125 years has been the range of techniques developed for forest management decision making that consider timber and non-timber outputs; incorporate public concerns and demands; and optimize economic, social, and environmental objectives. Economics-based forest management decision models began with traditional financial approaches described by Faustmann, offering managers a means by which alternative timber management strategies could be evaluated. This was followed by extensions to incorporate non-timber objectives, econometric techniques to assess multiple objectives and outputs, and mathematical optimization methods such as linear and goal programming. More recently, multi-criteria methods such as AHP have been introduced to incorporate social values into the decision-making process. To date, few researchers have traced the progression of these techniques over time. This presentation will briefly outline the evolution of the various techniques, beginning with basic financial approaches through mathematical optimization and multi-criteria models. Examples for each primary methodology will be provided and discussed, followed by a review of their advantages, disadvantages, and applicability for specific forest management problems.

Forest Management, Multi-Criteria Models

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1514 **Decision support model for sustainable and multifunctional forest management (FM) based on fuzzy and adaptive dynamic programming**

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Abstract: Sustainable and multifunctional forest management (FM) is extremely complex. It involves decisions on how to schedule investments, silvicultural, and harvesting activities over a long time horizon for maximizing profits, achieving ecological objectives, respecting societal needs, and addressing the uncertainties of natural, technological and socio-economic factors. As a consequence, modern FM necessitates developing decision support models (DSMs) to enhance the ability to understand, evaluate, and rank FM situations and decisions. First, a short overview of existing DSMs is provided, with the view on future research needs. This is followed by a description of the DSM which we have developed as an adaptive discrete dynamic programming, multi-criteria, fuzzy and hierarchical model. The FM process in this DSM is defined in terms of time periods, states, decisions, and weighted values of conflicting objective functions, which are determined with input from experts and stakeholders and then considered by group AHP as the cumulative utility of a decision. For defining subjective and uncertain variables which comprise the objective functions fuzzy methods are used. Ultimately, the utility that is maximized over all time periods is determined as sequential decision processes. The presented DSM is applied to an urban forest in Slovenia as a case study.

FM, DSM, multi-criteria, adaptive and fuzzy DDP

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1728 **Modeling optimal forest management and associated risks**

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Abstract: The study deals with modeling an economic decision-making of the forest manager supplying wood products. The consumer side is given by the product-specific demand function. An optimal control problem is formulated for a discrete system, reflecting the age-sequence of a forest stand. Control variables stand for the ratios of the forest harvested at every time period in every cell (forest type) and age-class. Associated risks are implemented via cell-specific mortality functions. The objective is to maximize the aggregated utility function over time. A high-dimensional bilinear control problem is solved using a discrete version of the Pontryagin maximum principle. The optimal solution is derived as a constructive rule, which helps to avoid computational difficulties arising in Bellman's principle and linear programming approaches. This rule is interpreted as an economic valuation of the harvesting time. We present modeling results for the case-study under a given price projection, forest type- and age-dependent cost functions, and biomass factors. The model structure, based on the allocation of forest areas into virtual cells and the use of corresponding multi-dimensional functions, provides flexibility in the problem formulations. The proposed framework can help formalize a forest management problem analyzing economic trade-offs between ecosystem services.

forest management, optimal control, risks

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79 - Decision support models (DSM) for optimal forest management (FM) with a glance to the past and a

K 5-7 (Konzerthaus Freiburg)

IUFRO17-310 **Application of group analytic hierarchy process in strategic forest management**

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Abstract: Decisions in forest resource management are complex because they should consider diverse, and possibly conflicting, ecological, economic and socio-political values. Strategic management requires employing analytical methods that maximize the forest functions and values that are frequently represented in the form of multi-criteria and indicators. Such complex decisions demand inclusion of various stakeholders. When stakeholders are not familiar with the chosen analytical method, linguistic rather than numeric evaluations are more suitable and easier to understand. The fuzzy analytic hierarchy process is one of the multi-criteria decision methods that incentive such group decision making. Although consensus is a desired result in group decision making, it is hard to achieve due to the diversity of opinions, knowledge and experiences of stakeholders. We propose an iterative soft consensus-based model where two stakeholders with the most dissimilar opinions are identified in each iteration and their judgments are adapted. The process is repeated until the desired consensus level is reached. In the application related to urban forested watersheds, we compare and discuss the soft consensus model and the well-known extent analysis method for deriving weights within the framework of fuzzy analytic hierarchy process. The results allow us to identify the benefits and costs of each.

fuzzy AHP, stakeholders, forest management

K 5-7 (Konzerthaus Freiburg)

IUFRO17-777 **Integration of strategic and tactical levels in the management of industrial forest plantations using multi-criteria optimization models**

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Abstract: As in other forest systems, forest management in industrial forest plantations is also divided into two hierarchical planning levels: strategic and tactical. Thus, we have strategic planning concerning basically with the maintenance of timber flow over a long period of time, while tactical planning concerns with short term harvest scheduling, by considering spatial considerations and production costs. These levels are strongly connected due to the short planning horizons and the intensive management planned in these plantations. However, the hierarchical idea according to the strategic solution is the ideal point in tactical planning seems not be optimal in these industrial plantations. Using a case study in Brazil, we have developed a multi-criteria decision making model in order to minimize the discrepancies between the two hierarchical levels. In short, an extended goal programming model, which takes into account several criteria belonging to both planning levels, has been defined with the help of diverse optimization modeling languages like Pyomo. Our findings s showed that the results obtained provide better solutions than the traditional hierarchical approach.

Pine, goal programming, spatial constraint

K 5-7 (Konzerthaus Freiburg)

IUFRO17-944 **Understanding the past, anticipating the future: assessment of recent changes in Slovenian forestry sector using qualitative methods**

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Abstract: The Slovenian forestry sector experienced vast changes after the transfer of ownership and management rights to private forest owners in the early 1990s. The purpose of our qualitative methods explanatory study is to highlight these changes in the Slovenian forestry sector and identify their influence on the activities of the Slovenia Forest Service (SFS). We interviewed forestry professionals employed at the SFS on the assumption that their perspectives are important in shaping the delivery of public service for supporting forest management decisions of private forest owners. The results reveal that private forest owners gained importance and the role of the public forest service shifted from being an active manager to providing management recommendations. The interviewees also noted mainly minor changes in the forestry sector in the last decade, yet the changes occurred consistently throughout the period and significantly influenced SFS activities. Moreover, the decrease in financial and human resources affected all aspects of the SFS, though enhanced overall efficiency. According to the interviewees the potential opportunities to confront these challenges encompass evaluating the SFS purposes and tasks, strengthening national forest governance, increasing educational activities, and enhancing the tools and technology of the agency.

public forest service, employees' perceptions

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79 - Decision support models (DSM) for optimal forest management (FM) with a glance to the past and a

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1765 **Optimisation of decision making in forest management planning of Central European pre-mature forest stands**

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Abstract: Forest management significantly affects the state of forest stands from multiple perspectives including their production, ecological and environmental functions. Environmental conditions (site and a stand type) are the most important factors that affect the differentiation of forest management in individual forest stands. The aim of this work is to specify an optimal thinning variant for a temperate forest of Central Europe that would ensure sustained production, ecological and environmental forest functions. The optimisation is based on the simulations performed by SIBYLA growth simulator and the method of the Reasonable Goals in combination with a Pareto frontier exploration technique known as Interactive Decision Maps (RGM/IDM). The growth of the forest stand was predicted with the growth simulator of SIBYLA by simulating the application of more than 140 different thinning variants identified in forest silviculture. The work presents a modern approach to decision making based upon up-to-date simulation techniques and assessment methods. The obtained results prove that environmental conditions and management goals significantly affect the optimal thinning management.

SIBYLA, interactive decision maps, silviculture

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3815 **A decision support system for climate change adaptation at the xeric forest limit**

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Abstract: In Hungary, most main, stand-forming tree species (e.g. spruce, beech, sessile oak) reach the lower (xeric) limits of their distribution within the country borders. Due to significant warming (by up to 1 °C since the 1960s) and decreasing precipitation, severe drought damages have already been observed in forests. To provide support for forest managers in selecting climate-tolerant tree species, provenances and adaptive technologies for future site conditions, is therefore an urgent need.
A preliminary decision support system providing projections and recommendations for discrete site types, has been developed. Building on site assessment criteria actually used in forest operational planning, the System provides GIS-supported site data and projections for the whole forest area of the country. Focusing on regional and local changes of site potential on forest compartment basis, options for tree species tolerating future climate scenarios as well as their expected yield and risks are proposed. Data and projections are available for recent past, current conditions, as well as for future reference periods until 2100. Further information on changes in hydrology, carbon cycling and biotic damages are under development for the System.
The decision support system is to be extended to other rain-fed sectors of agriculture (non-irrigated cultures and pastures) to offer the comparison between different land use options under expected climate scenarios.
The research is supported by the "Agroclimate-2" (VKSZ_12-1-2013-0034) joint EU-national research project.

climate change, adaptive species, decision support

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3469 **Analysis of timber harvesting behavior in forests in the northeastern United States**

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Harvest Probability; Forest Biometery

All Division 4 (Forest Assessment, Modelling and Management) Meeting

1 - Advances in the use of lidar data for forest carbon accounting

K 8 (Konzerthaus Freiburg)

IUFRO17-810 **Comparison of different types of auxiliary remote sensing data to improve estimates of biomass in dry African woodlands**

Næsset, E.* (1); Bollandsås, O. M. (1); Ene, L. (1); Hofstad Hansen, E. (1); Mauya, E. (2); Ørka, H. O. (1); Zahabu, E. (2); Gobakken, T. (1)

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Abstract: Remotely sensed data can greatly improve precision of estimates of biomass. This study estimated and compared precision of estimates of biomass in dry tropical miombo woodlands, a forest type that occupies nearly 9% of the African land area and is the dominant forest type in Eastern Africa. In a 365 km2 area in Tanzania a probability sample of 88 ground plots of the national forest inventory (NFI) was used in combination with complete-cover remotely sensed data from airborne laser scanning (ALS), RapidEye high-resolution optical data, and global forest maps from Landsat and ALOS PALSAR. The mean estimated biomass was 51.3 Mg/ha. The estimated variance of model-assisted estimates of mean biomass utilizing the various types of auxiliary data from remote sensing revealed relative efficiencies (RE) ranging from 1.3-1.4 when using the global maps to 3.3 (RapidEye) and 3.6 (ALS). RE was calculated as the ratio between the variance of a pure field-based estimate and the variance of the respective model-assisted estimates.

In a second survey covering miombo woodlands in a region of size 15,800 km2 that encompassed the smaller 365-km2 area, a systematic ALS strip survey was conducted by overpassing 513 NFI plots by ALS swaths with a mean width of 1350 m. The strips were parallel and spaced 5 km apart. The field and ALS surveys were conducted in 2012 and repeated in 2014, allowing estimation of biomass as well as biomass change. For biomass, the estimated mean was 58.7 Mg/ha and the RE values of the ALS-assisted survey using model-assisted estimators ranged from around 4 to 8 relative to pure field-based estimates. For biomass change, the mean estimate over the 2-yr period ranged between 0.11 and 0.35 Mg/ha, depending on estimator. RE values ranged between 1 and 7.

ALS, RapidEye, biomass, miombo, Tanzania

K 8 (Konzerthaus Freiburg)

IUFRO17-2999 **Integrating airborne and terrestrial laser scanning in designing new approaches to forest inventory sampling**

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Abstract: The most expensive part of a forest inventory is the collection of data in sampling units in the field. Sampling designs, statistical inference approaches and the use of remotely sensed data evolved in the recent years also aiming at augmenting the precision of the estimations while reducing the cost of the inventory.
Recently the technology behind the acquisition of field data in forest ecosystems with Terrestrial Laser Scanning (TLS) also rapidly evolved. The first systems were expensive and heavy and thus difficult to transport and to routinely operate in the field. The miniaturization of TLS and the evolution of software approaches for the automatic derivation of useful forest information from the raw point cloud are important elements which may bring to a more widespread use of this technology. Also in combination with remotely sensed data.
The contribution illustrates the recent advances in the use of static and mobile TLS systems for the acquisition of forest information in the field and propose possible new approaches in forest inventories based on the integration between TLS and Airborne Laser Scanning. Examples based on experimental field data acquired in Italy for forest carbon accounting with TLS are also presented.

Terrestrial Laser Scanning,Airborne Laser Scanning

K 8 (Konzerthaus Freiburg)

IUFRO17-2397 **Lidar-assisted national forest inventories: - for which variables and domains does it work well?**

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Abstract: Lidar-assisted forest inventories have emerged as cost-efficient for stand level assessments focusing on variables such as growing stock volume, biomass, and stand height. Further, they are currently being developed and applied for large-area inventories, such as national forest inventories, e.g. for proving information about carbon stocks and changes. However, most research studies focus on a limited set of variables within areas predefined as forest from existing land cover maps. In this study we assess the usefulness of lidar-assisted forest inventories for a variety of different variables of importance in national forest inventories and in carbon accounting. Further, we assess the performance of lidar-assisted surveys for domain-level reporting, in case the areal extent of the domains are not given by existing land cover maps. The study was conducted in a study area covering the interior parts of northern Sweden. Model-assisted estimation was applied for (i) estimating a set of different variables within areas predefined as forest and (ii) estimating areas of different domains-of-study as well as the biomass within these domains. In accordance with previous studies the lidar-assisted survey was found to provide accurate results for variables such as growing stock volume and biomass, but our study revealed shortcomings of the technique for other variables and for domain-level estimation.

sampling, model-assisted estimation

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1 - Advances in the use of lidar data for forest carbon accounting

K 8 (Konzerthaus Freiburg)

IUFRO17-1877 **Statistical issues with modeling individual tree aboveground biomass**

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Abstract: Aboveground biomass of trees is rarely measured directly. Instead, trees are destructively sampled in order to obtain data with which component biomass (bole, branch, foliage) may be estimated. Subsequently regression models are fitted using these biomass estimates as data for the response variable, coupled with measurements of tree size (usually dbh and height, sometimes crown ratio) as predictor variables in models for component biomass. All three are subject to measurement error. When wood density or specific gravity is also used as a predictor variable, it too is an approximation, inasmuch as wood density is not constant within a tree. In this contribution, the statistical consequences of sampling and measurement error on the model-based inference implicit in the development of biomass models is explored. We focus on the issue of the interpretation and meaning of model-based unbiasedness, as well as model-based estimates of precision of subsequent biomass predictions. We also will articulate recent advances in likelihood-based approaches for additive nonlinear biomass models.

measurement error; likelihood

K 8 (Konzerthaus Freiburg)

IUFRO17-2794 **A multi temporal ALS assessment to monitor the growth of above ground forest carbon in restored corridors connecting natural reserves in Brazil**

Amaral, L. G. . C. (1); Abib, T. H. (1); Laranja, D. C. . F. (1); Uezu, A. (2); Jenkins, C. (2); Lima, F. (2); Cullen, L. (2); Tenorio, S. (2); Rodriguez, L. C. . E.* (1)

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Abstract: In accordance with pledges signed during the 2016 UNFCCC convention in Paris, and defined in its intended Nationally Determined Contribution (iNDC), Brazil will reduce greenhouse gas emissions by 37% below 2005 levels in 2025. Among the pledged actions, the Brazilian government is set to promote the restoration and reforestation of 12 million hectares of forests for multiple purposes by 2030. Numerous forest restoration projects, using different funding strategies, have already been implemented over the last decades in Brazil. Hydroelectric power plants, for instance, in the Brazilian State of Sao Paulo have used earmarked funds to develop experiments dealing with the restoration of riparian forests on the banks of their large water reservoirs. Airborne laser scanning (ALS) techniques have been used to monitor the growth of such forests in terms of above ground biomass. This work reports on the analysis of multi temporal datasets from one of these initiatives. Models based on the 95th percentile, coefficient of variation and canopy density of return heights have generated accurate and affordable estimates. Carbon effectively captured and restored in riparian forests could be precisely monitored, showing that ALS can become an important tool to monitor the goals set by Brazil towards the Paris agreement.

forest restoration, LiDAR, riparian, biomass

K 8 (Konzerthaus Freiburg)

IUFRO17-4127 **Estimation of Trees Outside Forest Using LiDAR**

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Abstract: The world's forest has been degraded dramatically over time. Forest areas were converted to other land uses or destroyed. Moreover, there are billions of trees in the world that are not included in the Forest Resource Assessment definitions of "forest" and "other wooded land". Trees outside forest (TOF), trees on land not defined as forest and other wooded land are scattered on agricultural land, on meadows and pastures, on unproductive lands, on parks and gardens, around buildings and along canals, rivers, railways, and roads. They contribute roles and functions that are essential to agriculture, food security and economy. However, TOF data are scarce at the regional and global levels. In the Philippines, surveys of TOF in urban cities are few. This study aims to estimate TOF in Bi ñan City, Laguna using LiDAR. LiDAR or Light Detection and Ranging is a remote sensing method that generates precise three-dimensional information of the earth's surface. This study used OBIA in extracting TOF. Object based image analysis (OBIA) is state-of-the-art process in classifying high resolution images. The resulting map successfully extracted TOF in the city. This method may be used by remote sensing and geo-spatial analyst in cities with good accuracy in separating vegetation and non-vegetation features.

TOF, LiDAR, OBIA, high accuracy

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1 - Advances in the use of lidar data for forest carbon accounting

K 8 (Konzerthaus Freiburg)

IUFRO17-1614 **Using advanced airborne remote sensing as a sampling tool to support the forest inventory of interior Alaska**

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(1) USDA Forest Service, Pacific Northwest Research Station, Seattle, United States

Abstract: The development of cost-effective approaches to forest monitoring over large, remote regions, such as the boreal forests of interior Alaska, requires the efficient integration of sparse (and expensive) field plot measurements with information derived from airborne and satellite remote sensing data. In this study, we describe the application of a multi-level sampling design using field data, airborne lidar data, and satellite information to support the implementation of forest inventory in the Tanana valley of interior Alaska. In 2014, the USDA Forest Service Pacific Northwest Research Station established 100 inventory plots on a regular hexagonal grid within the Tanana Valley State Forest (728,000 ha) and Tetlin National Wildlife Refuge (283,000 ha) within interior Alaska. Measurements of all carbon pools, including trees (live and dead), down woody material, lichens/mosses, and soils were obtained on the field plots. During the same field season, NASA-Goddard acquired airborne lidar, hyperspectral, and thermal remote sensing data in single, parallel swaths covering these plots. We describe the statistical framework for integrating the information collected at the plots with lidar-derived structural measurements and composition (forest type) information derived from hyperspectral imagery. Estimates of forest carbon by forest-type - and uncertainty of these estimates -- obtained using this multi-level sampling design are compared to those obtained using standard, design-based inventory estimates from the field plots alone.

inventory, monitoring, lidar, hyperspectral

K 8 (Konzerthaus Freiburg)

IUFRO17-1104 **Hierarchical model-based inference with GLMM for forest inventories**

Saarela, S.* (1); Holm, S. (1); Grafström, A. (1); Schnell, S. (1); Petersson, H. (1); Gregoire, T. G. (2); Ståhl, G. (1)

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Abstract: Through the developments in remote sensing several levels of auxiliary information are becoming available for forest inventories. For cases when this information has a nested structure, e.g. wall-to-wall optical satellite data and a sample of laser scanning data, we propose that hierarchical model-based inference be applied. In this case two sets of models connecting the different levels of information are applied and in the assessment of uncertainties both sets of models must be accounted for. In this study we present model-based estimators and their variances. The models are fitted with generalized linear mixed models to account for data with a clustered structure, which is common in surveys of forest resources. The estimators were evaluated using Monte Carlo simulation in a fictitious population resembling forest conditions in a northern boreal forest. The target variable in our studies was growing stock volume. Our results show that the new estimators are at least approximately unbiased and that their precision depends on the goodness of fit of the regression models used, and the covariance matrix of the parameter estimators. Ignoring the uncertainty due to any of the models involved, e.g. ignoring the uncertainty in modeling growing stock volume from laser data, leads to substantial underestimation of the variance.

GLMM, Model-based inference

K 8 (Konzerthaus Freiburg)

IUFRO17-1082 **Sequential adaptive sampling for remote regions**

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Abstract: Although design-based estimators are commonly used for forest inventory applications, acquisition of the requisite probability samples for remote regions can be logistically difficult and extremely expensive. An alternative is to acquire non-probability samples for use with model-based inference whose validity is based on correct model specification, not probability samples. For forestry applications, almost no attention has been focused on optimizing non-probability sampling schemes for use with model-based estimators. Among such schemes, adaptive sampling uses sample data from previous stages to optimize sampling for the current stage with respect to a criterion such as the variance of the population mean. Sequential sampling entails assessment of a criterion of interest subsequent to each sampling stage. The combination of sequential and adaptive sampling both optimizes and minimizes the sampling effort, distinct advantages for sampling remote regions. For a study area in north central Minnesota in the United States of America, airborne laser scanning-assisted, sequential, adaptive sampling schemes were compared with respect to estimates of mean volume per unit area and their standard errors. The most important result was sequential, adaptive sampling schemes were developed that increased the precision of the estimator of mean volume per unit area while simultaneously minimizing both sample sizes and sampling related field crew travel.

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Forest information for bioeconomy outlooks – a joint session of the European National Forest Inventory

KG I - 1010 (Uni Freiburg)

IUFRO17-3879 **The politics of forest information in EU: mapping use, provision, gaps and challenges related to forest information exchange**

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Abstract: In the EU forest strategy, forest information is portrayed as a means to a better understanding and a better management of complex social and environmental challenges. Harmonization of relevant variables and parameters are described as key for mapping and assessing the state of forest ecosystems and the services they provide, and for allowing following up the management of EU forests. However, before forest focused and forest related information is harmonised across EU member states, and further developed to meet the information needs associated with complex social, environmental and economic challenges, it is central to have (a) a solid overview of the current use, needs for and provision of forest information across Europe, and of (b) the challenges experienced by policy practitioners and data provision experts regarding information use, provision and exchange. In this presentation, the Work Package 1 (WP1) of the DIABOLO project, presents research results based on surveys and interviews targeting users and providers of forest information across Europe. Based on the empirical results, WP1 describes a dominant use and provision of parameters that are forestry focused; identifies information gaps particularly when it comes to information related to nature conservation and biodiversity; and identifies challenges to information use, provision and exchange that encompass informal and formal rules, communication, data quality, resources and political interests.

KG I - 1010 (Uni Freiburg)

IUFRO17-3782 **Monitoring forest disturbances based on NFI field inventory and Sentinel2 time series imagery**

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Abstract: Monitoring forest disturbances based on NFI field inventory and Sentinel2 time series imagery
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Abstract
Spectral libraries are generated based on NFI field inventory data for different phenological phases and conditions of forests (e.g. spring / early summer / summer / autumn / dry condition, etc.). The spectral libraries are based on absolutely calibrated (atmospherically corrected and topographically normalized) satellite time series and field inventory plot data from national forest inventories. As the statistics are based on absolutely calibrated optical imagery, they can be fully automatically applied for estimation of forest parameters at the pixel level. The pixel level results are then aggregated according a user defined minimum mapping unit, e.g. minimum mapping unit of changes of 0.5 ha. The approach was applied both in Serbia as well as in the Black Forest - Upper Rhine Valley - Vosges region. Limitations and opportunities for this fully automated monitoring approach are discussed, e.g. near real time versus annual change monitoring with special emphasis on applicability at the continental, e.g. European level.

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IUFRO17-2332 **Current advances on mapping burned areas in Mediterranean with Sentinel-2 and Sentinel-1 data**

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(1) WSL, University of Patras, Cadenazzo, Switzerland; (2) University of Patras, Aginio, Greece; (3) Norwegian Institute of Bioeconomy Research, ÅS, Norway

Abstract: European Space Agency (ESA) is developing a series of satellites (called Sentinels) to provide satellite data especially for the operational needs of the Copernicus programme. Satellite data of Sentinel-1, a polar-orbiting radar imaging mission for land and ocean services, and Sentinel-2, a polar-orbiting, multispectral high-resolution imaging mission for land monitoring, are evaluated in this study for mapping burned areas in Mediterranean. Various study areas have been established initially in Greece and pre- and post-fire satellite data have been gathered and analyzed to characterize the post-fire signal or the signal change from pre- to post-fire .
With Sentinel-2 the emphasis is given on the extraction of spectral properties of burned surfaces and the estimation of the discrimination ability of each spectral channel possibly to be used for mapping the burned surfaces automatically. There is a long history of the use of Landsat data in burned land mapping mainly due to certain characteristics of Landsat imagery including the spatial, spectral and temporal data resolution, the cost (Landsat data are now freely available), and the existence of a more than 40-year historical archive. Sentinel-2 which actually is an improved instrument, as compared to Landsat, has not been fully evaluated and explored for burned land mapping. The first results show a spectral behavior similar to Landsat images at least on the similar spectral channels and prove that burned areas can be successfully identified and mapped in Sentinel data.
With Sentinel-1 we have detected an increase in backscatter intensity in the burned area, i.e. an increase as compared to the pre-fire data set. This increase follows reasonably well the outline of the burned area. However, the analyses are preliminary and more fine-tuning and filtering will be examined in order to remove noise in the change detection data set.

Bland mapping, Sentinel-1 and -2, Mediterranean

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Forest information for bioeconomy outlooks – a joint session of the European National Forest Inventory

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IUFRO17-2799 **The use of National Forest Inventory data for the conservation status assessment of Natura 2000 forest habitats in Europe**

Alberdi, I.* (1); Gasparini, P. (2); Dias, S. (3); Nunes, L. (3); Notarangelo, G. (2); Bonheme, I. (4); Kovac, M. (5); Castro Rego, F. (3); Cañellas, I. (1)

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Abstract: The European Union (EU) Directive on the conservation of natural habitats (Habitats Directive) is, together with the Directive on the conservation of wild birds (Birds Directive), one of the most relevant transnational legal tools for nature protection in Europe. However, there are differences across member states on the application of common definitions and guidelines used to assess conservation status and priorities. National Forest Inventories (NFIs) are valuable sources of information on forest habitat types (FHTs) and NFIs data are used in many countries to report on conservation status of FHTs.
In the frame of the H2020 DIABOLO project, an enquiry was carried out regarding the use on NFIs data, at the country level, to report on FHTs within the commitments of the Habitat Directive. The survey covered European countries accounting more than 55% of FHTs area in Europe. The enquiry was focused on the possibility to assess the structural and functional indicators through NFIs data.
The results of the survey highlight the differences and similarities concerning national definition of FHTs, the methods and data used for the assessment of conservation status indicators and the level at which NFIs data contribute to them.

DIABOLO, indicators, forest habitat, bioregion

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IUFRO17-2265 **Fire probability estimated by National Forest Inventories in Iberian Peninsula**

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Abstract: In the Iberian Peninsula there are about 280000ha of burned area each year. Although quite different in size of territory and population, Portugal and Spain share the same land, environmental conditions and fire propensity.
The relationship between fire and fuel variables, in particular the ones that measure vertical structure has gained increase attention in fuel models. In this study, the hypothesis of which are the most import fuel variables to predict the absence/existence of fire, after controlling for other factors such as climate and topographic variables, is explored. These relationships were estimated by data collected from the Portuguese and Spain National Forest Inventories, from 106 weather stations across Iberian Peninsula, from the Digital Elevation Model developed by the United States Geological Survey and using a dataset of wildfire recorded in Portugal and Spain.
A set of variables are selected to be include in a binomial logistic regression that predicts the probability of fire occurrence. The results corroborate previous studies, which coniferous stands are more vulnerable to fire, and low and open stands have a higher potential for fire. On the other hand, tall stands are related to reducing crown fire hazard. Vertical structure proves to be crucial to fire models.

fire probability, vertical structure, NFI

KG I - 1010 (Uni Freiburg)

IUFRO17-1847 **Development of national LULUCF GHG projection system: the implications for forest and land use policy in Lithuania**

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Abstract: The role of land use change and forestry in the aim to improve the balance of carbon emissions in Lithuania is considered to be highly important. Current operational GHG accounting and reporting system for Land Use, Land Use Change and Forestry sector is focused mainly on monitoring, however, the importance of related political and management decisions are increasing. Such decisions are usually followed with risks and uncertainties concerning acceleration of anthropogenic climate change, complex dynamics of evolving rural and forest governance, developing ownership structures and land-use patterns. The presentation would introduce methodological framework for projecting national carbon balance trends. The role of modern decision supporting tools, incorporating scenario modeling and behavior of involved actors, facilitating the recommendations for new coherent policy instruments and management strategies, will be discussed. The system of forestry and land-use scenario development is a part of Lithuanian National Forest Inventory by sampling method. It is built on a basic matrix structure defining a number of fixed states and modeling the transitions of the states over time. The discussion is concentrated around the potential dynamics of forest reference level, forest and land-use policy implications and sustainable development challenges at national level under different future alternatives. The study will be elaborated in the frames of two EU Horizon 2020 projects DIABOLO and ALTERFOR as well as national project FORESTRESS.

matrix method, scenario modeling, reference level

All Division 4 (Forest Assessment, Modelling and Management) Meeting

Forest information for bioeconomy outlooks – a joint session of the European National Forest Inventory

KG I - 1010 (Uni Freiburg)

IUFRO17-2215 **Timber production outlook: European Forestry Dynamics Model vs. German WEHAM**

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Abstract: There is an ongoing yet increasing demand at national and international level for information about future availability and development of forest resources for various ecological, economic or political planning purposes.

Germany uses a national forest growth model called WEHAM ("WaldEntwicklungs- und HolzAufkommensModellierung": Forest development and timber resource modelling) for the assessment of timber production and sustainability checks of management strategies. WEHAM is a modular empirical single tree forest growth model specifically designed to meet the requirements of the German national forest inventory (NFI) and to work with the data provided.

Besides Germany, there are various other national models in European countries specifically adapted to individual NFI needs and data structures.
However, within the scope of the European Forest Data Centre (EFDAC), the European Forestry Dynamics Model (EFDM) was developed in collaboration of former Metla and SLU. The aim of EFDM is to give enhanced harmonised information of the European forests state and dynamics despite various different climatic, ecological and socio-economic conditions, forest types and management strategies across countries. EFDM is a flexible free open source area-based Matrix Model. It uses transition matrices to express management activities (harvesting, thinning) and natural processes (growth, mortality).

During case studies, EFDM is tested for calculated even-aged pure forest stands in Germany (mixed stands subdivided into pure stands of equal age and tree species) and compared with the output of WEHAM. The specific results of this research with the most important differences, strength and weakness of both models will be presented. After all, EFDM tends to be more simple and transparent, flexible and expandable compared to the German national model. Anyhow, it still depends on NFI data and the detailed expert forestry knowledge of countries.

German NFI, wood supply, EFDM, WEHAM

KG I - 1010 (Uni Freiburg)

IUFRO17-3843 **A review of methodologies for analysing long-term sustainable biomass supply**

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Abstract: Biomass supply from forests has at least two different meanings. First, it refers to the amount of growing stock available for use. Second, it refers to the amount of biomass the producers are willing to make available at a certain price. From the inventory point of view, supply depends both on the actual amount of growing stock and on the regulation that controls the use of forests for wood supply. The regulation is context-specific, and varies a lot, for example, between European countries. From the economic point of view, supply depends on the supply and demand patterns. In recent years, different methodologies have been applied in the analysis of sustainable biomass supply. Most of them address supply from the inventory point of view. The objective of this paper is to review methodologies in terms of their ability to take into account complex and context-sensitive supply and demand patterns including dynamics of forests and forestry, different value-chains, different regulation measures and sustainability of supply (so called sustained yield).

supply, value-chains, dynamics, sustained yield

All Division 4 (Forest Assessment, Modelling and Management) Meeting

46 - European Climate Smart Forestry

K 5-7 (Konzerthaus Freiburg)

IUFRO17-4105 **Alternative climate change mitigation strategies and their relevance in European climate smart forestry**

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Abstract: Forests and the forest-based sector play an important role in climate change mitigation. In Europe, three levers of mitigation strategies are most relevant for climate smart forestry: sequestration management with focus on increased C sinks in forest biomass and soils (through forest protection OR increased productivity), sequestration management with focus on increased C sinks in harvested wood products (HWP), and substitution management with focus on the use of bioenergy and wood-based products to replace fossil fuels and non-renewable materials. This presentation briefly reviews the alternative strategies and discusses complementarity and trade-offs of forest-based climate change mitigation strategies. We then analyse impacts of alternative wood utilization scenarios on carbon in forests and harvested wood products using a case study from Lithuania. Four scenarios with increasing industrial wood supply for local industry and changes in product value chains were compared. The results indicated that climate change mitigation can be reconciled with national bioeconomy development targets when increased wood utilisation was combined with producing more long-life wood products. The case study illustrates that the assessment of climate change mitigation effects is strongly affected by system boundaries and accounting practices and that these factors need to be considered in forest resource use decision making.

carbon sink, harvested wood products, resource use

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2672 **How much wood can we expect from European forests?**

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Abstract: Forecasts for the coming decades predict an increasing demand for wood, not only in Europe but also globally. Wood energy plays a critical role in Europe's future renewable energy supply and the achievement of climate protection objectives, while increased use of wood products can substitute energy-intensive materials and store carbon. Part of this increased demand will be imported, but also European forests seem to be able to deliver more wood than is currently the case: compared to the 743 million m3 of wood that is annually growing in the EU28, only 523 million m3 is harvested (State of Europe's Forests 2015). However, much of this apparent potential will be difficult or impossible to mobilise in practice. A substantial amount is 'locked' in forests that belong to an estimated 16 million private forest owners. Additional constraints include accessibility of the forest, lack of machinery and skilled labour, priority to other forest functions and a mismatch between available species and sizes and demand. The EU H2020 project SIMWOOD investigated for 17 case study regions throughout the EU the current barriers for mobilisation and estimated how much of the apparent potential in these regions can be realistically mobilised and under what conditions. This was done based on a combination of analysis of repeated NFI observations, modelling based on NFI data and regional investigations among stakeholders. Based on an upscaling of these case studies, a more realistic supply level for the EU can be obtained.

wood mobilisation, small forest owners

K 5-7 (Konzerthaus Freiburg)

IUFRO17-4151 **Toward projections of an overall and comprehensive carbon balance of the forest sector**

PEYRON, J.-L.* (1)

(1) ECOFOR, PARIS, France

Abstract: Forests are able to mitigate climate change through carbon sequestration, storage, and substitution. But these different options are generally conflicting. How should they be combined? This question is a first major challenge for forest management and policy. Adaptation and mitigation have to be distinguished because they are very different responses to climate change. In the same time, they are interrelated since mitigation depends on forest adaptation. The integration of climate change impacts on forest mitigation is a second challenge. Finally, climate change issues are only a part of sustainable forest management and trade-offs also exist between climate change measures and sustainability at large. This presentation will comment these issues from models running at country levels. It will argue for the need to project during several decades an overall and comprehensive carbon balance of the forest sector under climate scenarios and management options.

Mitigation substitution sequestration projections

All Division 4 (Forest Assessment, Modelling and Management) Meeting

46 - European Climate Smart Forestry

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3707 **Impact of governance instruments on wood supply in a climate change environment**

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Abstract: Forest area amounts to 34.5% of the land area in Portugal. Around 84.2% of this area is made up of private forests owned by small-scale owners of which only 13% are members of forest owners associations. Eucalyptus and maritime pine make up 50% of the forest cover and are the main wood-production species and the raw-material for the prosperous pulp-industry. Notwithstanding, over the past decades disturbances such as wildfires and insect outbreaks combined with over-harvesting, late re-conversion of 4th-5th generation coppice and deficient management have had the greatest negative impact on forest structure and wood availability resulting in high imports to satisfy wood demand. Minimizing such impacts, which can be further magnified under climate change, is one of the proposed targets in the Portuguese Forest Strategy together with the restoration of degraded forests, the promotion of sustainable forest management and increasing forest productivity. The success in achieving the proposed goals depends upon investing in mechanisms for combining regulatory, economic and information instruments. Therefore, several alternative policy scenarios will be tested to assess the impact of governance instruments on wood supply/demand (e.g. subsidies to delay harvest age, regulating tree species selection for reforestation/afforestation, replanting deficient-managed areas using resources at reduced costs).

Governance,adaptive management,wood supply,climate

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1551 **European climate smart forestry**

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Abstract: Forests in the European Union comprise 161 million ha and play a significant role in the EU carbon budget with a contemporary overall mitigation effect of 13% of total EU emissions, or 569 Mt CO2 a-1.
Based on existing literature, we estimate this forest role can be enhanced with an additional 450 Mt CO2 a-1 by 2050, provided the right incentives are set. We label the needed policies, incentives and actions "Climate Smart Forestry" (CSF). CSF aims to tackle three main objectives: sustainably increasing forest productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions. CSF will most optimally function based on a regionally and temporally intelligent governance and implementation, from the forest to the wood chain. European forests are most optimally set for this because they have been managed for centuries already.

In this session we will present and discuss the options in European forestry under Climate Smart Forestry. From various geographical regions the whoel chain in forest ecosystems, harvested wood products and bio energy wil be presented. This session opening will give an update of latest developments.

European forests, mitigation,

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1914 **Regional forest productivity and economy designate European Climate Smart Forestry**

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Abstract: Forests are the main terrestrial reservoir of carbon storage with European temperate and boreal forests sinking 13% of European annual carbon emissions. Forest carbon density can be manipulated through management interventions to maximize climate mitigation potentials. However, such a Climate Smart Forestry should take into account regional differences in growth conditions and forest products economy. Here, we realize European Climate Smart Forestry applying the process-based forest growth model 4C coupled with a multi-objective goal programming optimization algorithm. By computing the trade-off between carbon sequestration and commercial wood production, the "carbon cost" is defined as the economic loss by favoring more mitigation. Future cash flows (NPV) and carbon mitigation (PTE) are discounted to account for time preferences and fluctuations. Accordingly, the maximum European carbon costs are estimated to be EUR 74.59 (±2.3) /PTE being marginally above estimated global average (e.g. EUR 53 /PTE). We find an optimal solution for carbon oriented forestry in countries with a high and increasing carbon budget and low carbon costs. However, the current level of European carbon market price of EUR 28.23/PTE would realize 7.9 Billion PTE carbon. European Climate Smart Forestry may contribute to COP21 goals by mitigating over 12 Billion PTE carbon in 21st century and the total carbon costs of 600 Billion ###.

Goal Programming, Carbon Forestry, Carbon Costs

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46 - European Climate Smart Forestry

K 5-7 (Konzerthaus Freiburg)

IUFRO17-964 **Inclusion of aerosols is essential for analysing the climate impacts of boreal forest use**

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Abstract: The mitigation potential of forest management on climate change has been widely debated recently. Thus, our study aimed to quantify the total climate effects of boreal forest use. For the first time, this study has combined in the means of modelling the effects of carbon sequestration in forest ecosystems and wood products, the avoidance of CO2 emissions from fossil fuel use by product substitution, albedo and the direct and indirect forcing of secondary organic aerosols (SOA). The simulations over rotation periods were conducted for the stands of Norway spruce, Scots pine and silver birch both in current and projected 2050 climate. The scope of this presentation is in the last one: volatiles emitted from different boreal trees, the subsequently formed secondary organic aerosols and their climate impacts. For the conifers, the SOA effect more than cancelled the warming induced by the low albedo of coniferous forests, and the cooling effect increased further in the predicted warmer climate. Birch was found to have an ample cooling effect to which SOA and carbon sequestration influenced in about equal shares. The species-specific differences in radiative forcing were mainly caused by the different emission rates of volatile organic compounds and the subsequent variation in SOA production in the atmosphere. Thus, species selection favoring broadleaved species, which emit more volatiles, can be an equivalent or more important consideration to earlier reported albedo effects for managing boreal forests to mitigate climate change. Our study demonstrated that the decision on climate-cooling forest management requires a holistic consideration of all associated effects, and that appropriate management of boreal forests can have an important role in climate change mitigation.

radiative forcing climate boreal aerosol albedo

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67 - Managerial Economics and Accounting: Where We have Been & Where We Can Go

K 1 (Konzerthaus Freiburg)

IUFRO17-1220 **What a Long Strange Trip It's Been: A Look Back at 125 Years of Managerial Economics and Accounting**

Hodges, D. G.* (1); Zadnik-Stirn, L. (2); Sekot, W. (3); Afonso Hoeflich, V. (4); Peyron, J.-L. (5)

(1) University of Tennessee, Natural Resource Policy Center, Knoxville, TN, United States; (2) University of Ljubljana, Biotechnical Faculty, Ljubljana, Slovenia; (3) University of Natural Resources and Life Sciences, Institute of Agricultural and Forestry Economics , Vienna, Austria; (4) Universidade Federal do Paraná, Curitiba, Brazil; (5) GIP - ECOFOR, Paris, France

Abstract: The disciplines of forest economics and accounting have evolved substantially since the establishment of IUFRO. In fact, both areas have largely emerged since the organization's founding in 1892. Although attention was focused on the economics of forest management before Faustmann's 1849 work, forest economics as it is understood today was recognized as a separate discipline much later. Since that time, forest economics and accounting have evolved substantially. These include a number of significant contributions to forestry and resource economics such as economic tools to assess traditional forest management alternatives and multiple use forestry, national accounting procedures to incorporate the forest sector and its contributions, green accounting, valuation techniques for non-market and non-timber forest goods and services, multi-criteria decision tools, and contributions to sustainable forest management. This presentation will review this history of forest economics and accounting since the late 1800s, offering insights into the primary contributions of the disciplines and serving as an introduction to the subsequent forward looking presentation in this session. Additionally, the history of IUFRO Working Group 4.05.00 and its contributions to the disciplines will be reviewed.

Managerial Economics, Accounting, History

K 1 (Konzerthaus Freiburg)

IUFRO17-1736 **Forest Management and Public policy in Fast Growing Plantations: Past, Present and Future**

Morales Olmos, V.* (1); Hoeflich, V. A. (2)

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Abstract: Forest policies in fast growing plantations have been evolving in different ways. Several similarities can be identified, however. Some have provided economic incentives to develop the forest activities. Forests provide not only timber products but also non-market services. These diverse services could be classified in some cases as public goods. Therefore, public policies should ensure the correct classification of these goods. Furthermore, the opportunity cost of the capital in forest investments is related to the long term nature of these investments. Another argument involves the attractiveness of these opportunities to investors in the sector. In Latin America, public policies to incentive the development of fast growing plantations started in the 1970s. Chile, Brazil and Uruguay developed their forest sectors under this type of policies. This research reviews these policies and the current situation of these three forest sectors. Finally, an overview of the future of the fast growing plantations in South America is provided.

forest policy, Latin America, forest services

K 1 (Konzerthaus Freiburg)

IUFRO17-2774 **Economics of wood-based bioenergy: review of the past and an exploration of future research directions and policy deliberations**

Grebner, D.* (1); Joshi, O. (2); Perez-Verdin, G. (3)

(1) Mississippi State University, Department of Forestry, Mississippi State, United States; (2) Oklahoma State University, Department of Natural Resource Ecology and Management, Stillwater, United States; (3) Instituto Politecnico Nacional, CIIDIR, Durango, Mexico

Abstract: The development of wood-based bioenergy has been a national interest in the United States for several decades dating back primarily to at least the oil crises of the 1970s. The level of interest and financial support for scientific investigation has waxed and waned over the years depending on the current price of petroleum. During the mid-2000s, interest peaked again along with greater research output, but interest has declined since that point. This study presents a review of what has been done in the past as well as an exploration of what needs to be done in the future. The methodological approach will include a review of the literature of what has been done and qualitatively identify gaps in our knowledge base. The expected results will be useful in helping researchers and policy makers understand what we know and don't know.

Bioenergy, economics, review, research directions

K 1 (Konzerthaus Freiburg)

IUFRO17-2201 **Advancing the Valuation and Measurement of Forest Ecosystem Services: Future Research/Management Directions**

Japelj, A.* (1); Poudyal, N. C. (2); Bosch, M. (3); Hodges, D. G. (2)

(1) Slovenian Forestry Institute, Ljubljana, Slovenia; (2) University of Tennessee, Knoxville, United States; (3) Johann Heinrich von Thünen Institute, Hamburg-Bergedorf, Germany

Abstract: Forest management historically has been focused on timber production and the resulting wood products. Ecosystem services have remained undervalued, if not ignored, by most forest managers and policy makers until recently, when several researchers began evaluating their value. Today, policy makers, landowners, and managers recognize that forests provide a wide range of environmental, economic, and aesthetic benefits for society such as biodiversity, carbon sequestration, and water and air quality protection. While there have been wide range of research conducted on the economic values of forest ecosystem services, many questions remain unanswered. This presentation will identify the primary unknowns and provide insights into future research opportunities to address them. Specific topics will include bundling and stacking ecosystem services, alternative approaches to ecosystem service mapping and their implications for estimating values at a landscape scale, and new methodological approaches such as conjoint optimization. The goal is to identify a potential research agenda for future work on valuing forest ecosystem services.

Ecosystem Services, Conjoint Optimization

All Division 4 (Forest Assessment, Modelling and Management) Meeting

67 - Managerial Economics and Accounting: Where We have Been & Where We Can Go

K 1 (Konzerthaus Freiburg)

IUFRO17-1597 **Rules of thumb for invasive species rapid response based on bioeconomic rates of return**

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Abstract: Faced with a growing list of invasive species and limited budgets to respond to their impacts, state and federal agencies must prioritize control effort based on the present value of the net benefits from control. Unfortunately the amount of data required to calculate net benefits generally prevents such a prioritization at the time scales needed for rapid response. An alternative is to compare the rate of return from invasive species control to the market rate of return earned by investments elsewhere in the economy. This approach quickly identifies those species where control expenditures may be better spent elsewhere from those that necessitate immediate attention. This paper presents a framework for estimating expected rates of return from invasive species control decisions based on both ecological and economic factors. These expected bioeconomic rates of return can be used to determine invasive species where control is not currently justified based on the time value of control expenditures. Spread data on twelve well-known invasive species is used to illustrate results. Based on reasonable assumptions concerning the human response to invaded area, a control response that reversed the spread of the species would be needed to justify an immediate investment in control.

real options, portfolio theory, species spread

K 1 (Konzerthaus Freiburg)

IUFRO17-1288 **The Future of Forest Management: Developing a Theory of Planning**

Kovac, M.* (1); Hodges, D. G. (2)

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Abstract: Forest management planning began in the 17th century, while the first scientific approaches provided by Cotta, Hartig, and Judeich were brought to light two centuries later. Today, the scope of planning varies from large-scale strategic (general) plans for all forests within a nation's boundaries, to small-scale operational (detailed) management plans that optimize specific objectives for large public or industrial holdings, to written or unwritten plans for small privately-owned tracts. All plans have a set of common traits, although the specificity varies considerably - a set of management objectives (sometimes implicit), summary of resources, management strategies for achieving the objectives, and processes by which success can be measured (although this component is often lacking). To date, however, little work has been done to develop a theory of forest management planning. Little is known, for example, about the theoretical basis for forest management planning: is it based on a sole theory or on comprehensive theories from other fields such as sociology, political science, and planning? Regardless, practical experience and realization of plans reveal that planning must fulfill certain standards. These standards are not only procedural in nature but also include the organization of society, democracy, and functioning and openess of society - including public discourse. This presentation attempts to incorporate the theoretical foundations of forest management planning from planning, political science, and sociology in an effort to develop a comprehensive framework to be used in natural resource planning.

Forest Management Planning, Objectives, Theory

K 1 (Konzerthaus Freiburg)

IUFRO17-1462 **Experimental Analysis of the Climate Change Impact on Forest Economics in a Selected Territory of the Czech Republic**

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Abstract: The economic impacts of the expected climate change on forestry are theoretically addressed in many countries, including the Czech Republic (CR). The paper brings a concrete analysis of the estimated impact on forest economics in five river basin areas in the south-eastern part of CR characterized by above-average temperatures and below-average precipitation, and significantly threatened by the climate change. It is the first experimental analysis in CR investigating the economic impact, and identifying and verifying methodological approaches and problems.
The impacts were estimated for three periods - from now to 2040, 2041-2070 and 2071-2099. In the case studies, the average annual forest-production yield was taken for the key indicator of the economic impact. The results show a high future economic loss caused by the change of the tree-species composition where the oak, pine and beech will gradually replace the Norway spruce. The average annual yield from the total of 53 thous. ha of forests in the analysed river basins will decrease significantly: from the present CZK 30.3 mil. to CZK 13.1 mil. (43%) in 2041-2070 and to mere CZK 9.9 mil. (33%) in 2071-2099. Nonetheless, in all cases, the economic result will remain positive.

Economics, climate change, threatened forests, CR

All Division 4 (Forest Assessment, Modelling and Management) Meeting

67 - Managerial Economics and Accounting: Where We have Been & Where We Can Go

K 1 (Konzerthaus Freiburg)

IUFRO17-1284 **Return on wood production by tree species**

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(2) University of Gävle, Department of Business and Economic Studies, Gävle, Sweden

Abstract: What is the cost of producing cubic metre pine? What is the production function? These questions are challenges although cost accounting has been done for years However, the cost accounting is typically applied at the forest holding level. The life of an individual stand, for example, is too long to cope with.

In case, the national forest inventory as well as stumpage price and cost statistics are accurate, return on forest ownership by tree species provides a proxy for economic results and comparison. The solutions are extensions of the return on forest ownership results in production for ten years in the statistical service at Natural Resources Institute Finland. The key challenges are the splits of the growing stock e.g. between non-industrial private forests and the others, between tree species as well as splits of the costs between tree species. A method to split the wood production costs is hard to find. As a proxy, the costs were split using timber sale earnings.

It turns out that the average returns 1983-2015 have 2.5% for pine, 3.1 for spruce and 2.6 for birch, spruce being the best choice. Surprisingly, with time period 1993-2015 the respective figures were 4.3%, 4.7% and 3.8% and with 1983-1993 negative because of the recession. The recent results of period 2003-2015 turn with 3.7%, 3.5% and 3.3% pine being the best choice. The standard deviations 10.6%, 10.1% and 10.0% hardly differ from each other. In all, spruce might be the best choice in case the sites suit for spruce. In all, the most dominating driver were price ups like in 2007 and lows in 1990s emphasising the well being of the forest industry.

return on forest ownership, prices, costs, NFI

All Division 4 (Forest Assessment, Modelling and Management) Meeting

15 - Impacts of environmental changes on growth and productivity of managed and unmanaged forests

K 2-4 (Konzerthaus Freiburg)

IUFRO17-294 **Environment-induced growth changes in the Finnish forests during 1971 - 2010 - an analysis based on National Forest Inventory**

Henttonen, H. M. (1); Nöjd, P. (2); Mäkinen, H.* (2)

(1) Natural Resources Institute Finland, Helsinki, Finland; (2) Natural Resources Institute Finland, Vantaa, Finland

Abstract: The annual growth of the forests of Finland has more than doubled in less than a century. The aim of our study was to quantify the magnitude of changes of volume, basal area and height increment not attributable to changes in growing stock, forest structure and silvicultural practices.

We used the data from National Forest Inventories during 1971 - 2010 to develop models for volume, basal area and height increment of individual trees on mineral soils without ditching or paludification with tree and stand characteristics as predictor variables. Differences between the measured and predicted increment were used to detect environment-induced increment changes. Using this approach it was also possible to approximate the enhancing effects of volume increment change in growing stock volume.

From 1971 - 1975 to 2006 - 2010, the environment-induced volume increment increase was 8.98 million m3 a-1 (0.69 m3 ha-1 a-1), which equals to 37% of the total observed volume increment increase. In relative terms the environment-induced increment increase was larger in the northern regions (up to 45% of volume increment change). During 1971 - 1990, the difference between the observed and predicted change was small. A large shift was observed after the mid-1990s in all regions. While the environment-induced increment change was substantial, a considerably larger increase 63 % of the change was attributed to growing stock volume and forest structure, which both changed due to differences in forest management.

A comparison between the environment-induced increment changes and growing season temperature sums revealed similarities. In the southern Finland, April-May seemed to be influential, while in the north the temperature sum of May-September showed similar variation. As climate change is predicted to increase growing season temperatures, the trend can be expected to continue in the boreal conditions of Finland.

environmental change; forest growth; growth trend

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1849 **NFI-based investigations of recent changes in forest growth in Western Europe: variations across tree species, geographical scales, and climatic contexts**

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Abstract: Context. National forest inventories (NFI) have been little used to explore forest growth changes due to their limited temporal cover. Strong recent climatic warming renews their interest. The systematic and repeated cover of forest areas further enables explorations across a broad range of tree species and climatic gradients, and across spatial scales.

Approach. Using the French NFI, we estimated recent growth (Basal Area Increment/ha) changes (1980-2007) in eight coniferous and broadleaved trees species growing in mountain, temperate and Mediterranean contexts of Western Europe. Growth changes were inferred as averages over whole NFI samples, regional subsamples, and mapped regionally using geographically weighted regression. They were correlated with indicators of baseline climate and climatic change.

Results. Major species differences in BAI changes were found, spanning from -17% to +42% over 1980-2007. BAI strongly increased for mountain species, showed moderate increase/no change for temperate lowland species, and unexpectedly declined for Mediterranean species. Within-species regional differences in these changes were of comparable magnitude. Growth change mapping revealed strong variations and systematic local sign inversions. BAI changes were found greater in colder/wetter contexts than in warmer/drier ones where declines were observed. Warming was detected across all species samples and strongly correlated with species BAI changes.

forest growth; climate warming; tree species; NFI

All Division 4 (Forest Assessment, Modelling and Management) Meeting

15 - Impacts of environmental changes on growth and productivity of managed and unmanaged forests

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2382 **Recent growth trends for main European tree species and their drivers**

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Abstract: In the 1990s growth studies showed a trend of increased growth, explained mainly by nitrogen deposition. More recent studies have reported negative trends explained by climate change. In this study we perform a meta-analysis of studies from the last 30 years to assess the observed growth trends in temperate European forests. We focus on the important timber species pedunculate and sessile oak, beech, Scots and black pine, silver fir and Norway spruce. Studies based on multitemporal assessment of current annual increment, either from tree ring analysis, resampling of inventory plots, or monitoring of dedicated growth experiments, are included. One of the major challenges of growth trend studies of trees is the disentangling of time from tree age effects. We addressed this by including studies with data from different age cohorts. In addition to the trends, we also consider the drivers, from studies where their relationship with growth has been tested.
The results show that in several regions the earlier observed positive growth trend has slowed down over the last decades, or even reversed into a negative trend. However, this transition cannot be generalised over all regions and species. Drivers of observed growth trends are multiple. Nitrogen deposition is generally associated with positive growth trends, but in particular regions, nitrogen saturation seems to have led to negative effects. CO2 increases have contributed to the positive trend, but seem to be increasingly overruled by climate change effects provoking negative growth trends, such as decreased air humidity in summer, and increased occurrence of drought events. The most overlooked factor of growth trend changes, however, is forest management. While it is a basic principle of forestry that management style has a strong effect on diameter growth, it is often not taken into account in growth trend studies by lack of data. We recommend therefore to mapping historical management trends more in detail.

tree ring, inventory, climate change, management

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2197 **Increased Production of Norway Spruce: An examination of the effects of climate change in managed and unmanaged forests in Norway**

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Abstract: Under changing climatic conditions, the validity of predicted productivity from forest growth models developed from data collected prior to those changing conditions becomes uncertain. The implication is that current models used for making management decisions, or for developing forest and climate policy, may result in biased predictions which can lead to misguided planning. Data from long term research trials of Norway spruce established in stands planted between years 1920 to 1950 and covering almost six decades of measurements (1957-2016) were used to examine the changes in annual productivity in southeastern and central Norway. Results indicated large increases in productivity beginning in the year 1990 and thereafter. After accounting for the effects of stand variables, such as age, site productivity, and stand density, on production, an analysis of climatic data indicated that the main drivers of the observed increased in production were extended growing seasons and increasing growing degree days (GDD). On the average, growing seasons increased by as much as 20% while the GDDs increased as much as 50%. A forest growth model was developed to incorporate effects of climate variables such as temperature and precipitation, among other environmental factors. The model has the ability to account for changing climatic conditions and can be used for evaluating current growth models and forecasting future productivity under different climate scenarios.

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3891 **Growth and mortality analyses in central European forest ecosystems based on long-term monitoring and gradient studies**

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Abstract: In recent years an increasing number of studies have reported on forest declines, growth reductions and increasing mortality rates in response to changing climatic conditions. Climate change scenarios suggest an increase in temperature and extreme drought events for many regions worldwide, indicating increasing limitations of growth performance of many forest ecosystems. But how is the response today across the different forest ecosystems? Are respective trends in growth and mortality already observable, and if yes, which tree species are concerned?
We synthesized several studies analyzing 100 years of mortality data from long-term monitoring networks in Switzerland, including the National Forest Inventory, the long-term forest ecosystem research program (level II), the forest reserves, and growth and yield plots. In addition tree-growth responses to climatic variations and extreme drought events were analyzed along environmental gradients.
The species-specific growth sensitivity to climate and severe drought along environmental gradients revealed for the drier sites a strong reduction of radial growth due to soil water deficits in previous autumn and current spring, whereas at moist sites summer drought impeded growth. High soil water holding capacity showed up being an effective buffer to reduce the impact of extreme drought. Subalpine forests showed low temperatures as main limiting factor and almost no growth limitation due to drought.
The tree mortality data revealed surprisingly no increasing trends for most of the main tree species. The only exception is Scots pine growing on low elevation sites, where drought induced mortality increasingly occurs. Other trees species, such as spruce, silver fir and beech showed periods of increased mortality but mainly related to climatic extremes and subsequent biotic factors such as bark beetles. Hence the future performance of Central European forests will predominantly depend on the frequency of hot and dry spells.

drought, monitoring, tree growth, tree mortality

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K 2-4 (Konzerthaus Freiburg)

IUFRO17-457 **Norway spruce trees long-term growth with account for possible climate change in the Leningrad Region of Russian Federation.**

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(1) Saint-Petersburg State Forest Technical University, Saint-Petersburg, Russian Federation; (2) Nepal Red Cross Society, Kathmandu, Nepal

Abstract: Study area Lisino training and experimental forest is located in the central part of Leningrad region and has high level of protection as a forest of scientific and historical value. According to official data mean annual temperature in the region increased by 0.6 °C/10 years as well as precipitation. The impacts of changing climate conditions on Norway spruce trees growth was the aim of this study. Three most representative compartments dominated by Norway spruce were selected for data collection. Samples were taken as a core by Pressler borer from 107 dominant trees while climatic data were taken from closest meteorological stations. Tree rings were measured and analyzed by using WinDendro technologies while climate data were studied by excel. Tree ring data cover the time interval from 1850 to 2011, each ring was characterized by width, calendar year, age and diameter of tree. Radial growth was analyzed within age and diameter classes. Annual rings widths were varied from 0.1 mm to 6mm. There was a positive trend in age classes 0-20, 21-40 and 41-60. The growth was very slow in age classes 61-80, 81-100 and >100. Diameters are higher in age classes 20-40 and 41-60 years old as compare to local diameter growth table which was developed in nineteen century. Diameters for age classes older than 41-60 years were less than prescribed by diameter growth table. Tree rings width for all age classes also demonstrate cyclic dynamics, sometimes decline fall down on last decades. Multiple regression was used for developing response function to relate climate and growth data. There was revealed a high correlation (90%) and low influence of vegetation period climate data on growth during 1850 to 2011 (0.08102 mm/ ºC and 0.00085 mm/mm). Likewise, analysis shows the growths is higher in young and middle age classes than mature and over mature. Overall, climate change impact has seen positive in growth of Norway spruce trees for study area but not for all age and diameter classes.

Climate change, growth, temperature, precipitation

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1184 **Forest Decline in the Black Forest - What happened in the last 40 years?**

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Abstract: The European wide discussion on forest decline started in the year 1979 in the foothills of the Black Forest. Air pollution was at that time hypothesized to be the main cause of this decline. This presentation analyses the extent of the decline and discusses possible causes. The decline is described by tree mortality statistics and by the variation in tree growth. For the analysis of possible causes, climate and air pollution records are taken into account. Climate variation is identified as the main driver of mortality and variation in tree growth. Warm summers combined with low precipitation during the growing season reduced tree growth and led to an increase of the rate of mortality.

Black Forest Decline, Climate, Growth, Mortality

K 2-4 (Konzerthaus Freiburg)

IUFRO17-677 **Modelling climatic effects on site productivity of jack pine and black spruce plantations**

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Abstract: Climatic effects on site productivity of jack pine (Pinus banksiana Lamb.) and black spruce (Picea mariana Mill. B.S.P.) plantations were examined. Dominant or co-dominant trees sampled from 73 plots for jack pine and 75 plots for black spruce were used in the analysis. Site index (SI) (a measure of site productivity) was regressed against climatic variables to examine the climatic effects. For jack pine, total precipitation and mean temperature of the growing season, wettest period (precipitation of the wettest month), total precipitation of driest period (precipitation of the driest month), and the interaction of annual precipitation with mean annual temperature explained 39% of variability in SI. For black spruce, mean temperature and total precipitation of the growing season, Julian day at the end of the growing season and its quadratic transformation, total precipitation of wettest period and its quadratic transformation, quadratic transformation of annual mean temperature, and the interaction of Julian day at the start of growing season with maximum annual temperature explained 48% of variability in SI.
Climatic variables that were significant in the regression were incorporated into the stand height growth models. However, only growing season's total precipitation and mean temperature were significant in the growth models for both species.

height growth, growth and yield

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K 2-4 (Konzerthaus Freiburg)

IUFRO17-2032 **Nonlinear mixed models for tree growth: Combining climate, site, stand, management, and nutrient effects**

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Abstract: Empirical forest scenario models are used in several contexts, e.g. to evaluate management strategies, to predict potential timber supply, or to estimate carbon sequestration. As key parts of such models, the growth functions are supposed to incorporate a large variety of influencing factors while representing large spatial extents. In recent times, the demand to include effects of climate change into scenario models has increased. Thus, the present study aimed at empirically modelling effects of climate and N-deposition on tree growth, while simultaneously considering effects of stand, management and site properties.
Nonlinear mixed-effects models with covariates were fitted to individual-tree basal area increment (BAI) data from the Swiss National Forest Inventory. Data from 1983-2006 were used for model fitting, data from 2009-2013 for model evaluation. A total of 24 potential explanatory variables were included into a variable selection procedure that was performed separately for spruce, fir, pine, larch, further conifers, beech, oak, ash/maple, and further broadleaves.
The combinations of selected variables differed among the species, well reflecting their physiological properties. In general, BAI was positively related to DBH, and negatively related to slope, basal area of larger trees, stand density (not so for the shade tolerant beech), mean DBH of the 100 thickest trees per ha, and soil pH. For most species, a positive harvesting effect was identified. Increasing N-deposition resulted in increasing BAI, except for spruce and fir, for which the models indicated an inverse effect. Drought proved to be relevant for most species, except for pine and oak.
As a next step, the developed growth functions may be incorporated in empirical forest scenario models and used for nationwide scenario analyses as well as for applications in other parts of central Europe represented in Switzerland's large environmental gradients.

Basal area increment, Empirical growth models

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3105 **A dynamic environment-sensitive site index model for the prediction of site productivity potential under climate change**

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(1) Department of forest growth, FVA, Freiburg, Germany; (2) University of Freiburg , Freiburg, Germany

Abstract: Accurate and reliable predictions of the future development of forest site productivity are crucial for the effective management of forest stands. Static models which extrapolate productivity into the future are inappropriate under conditions of environmental change since they lack a close link between fundamental environmental drivers and forest growth processes. Here we present a dynamic environment-sensitive site index model formulated in the framework of a nonlinear state space approach based on longitudinal data from long-term experimental plots. Estimation of the model parameters was carried out using the prediction error minimization method. Our aim was to identify dynamic relationships between site index and environmental variables and to make conditional predictions of the future development of site index under climate change scenarios. Nonlinear, interactive, as well as accumulative effects of environmental factors (climate/weather and nitrogen influx) on the growth response were considered in the model. In the study, we estimated the dynamic environment-sensitive site index model using data from 604 Norway spruce (Picea abies [L.] Karst.) long-term experimental plots in southwest Germany with measurement data covering a period of more than 100 years from the end of the 19th century until today. We used the calibrated model to project future site index changes under increasing growing season temperature scenarios.

dynamic modeling, site productivity changes

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2671 **Developing individual-tree diameter growth functions for Europe**

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Abstract: Over the last decades, many growth and yield functions have been developed in European countries. They are usually based on large national datasets, obtained from National Forest Inventories or from long-term research plots. The predictors included in these models can give important information on behaviour of tree growth in relation to climate, soil and other environmental variables. However, many of these functions are based on country-specific datasets and/or methods, such as site quality indices that may aggregate climate, soil properties and topography effects. Consequently, it is difficult to compare such functions among countries, and often impossible to apply functions outside the region or country it was developed for. Furthermore, at a larger geographic scale the importance of environmental predictors may change due to a larger observed range.

Here we report on a set of diameter growth equations for which parameters are estimated using a dataset of measured diameter growth of over 2 million trees from 10 National Forest Inventories in Europe. We discuss how these growth equations provide insight in the most dominant climatic, soil and topographic parameters governing tree growth. Using these growth equations we map growth conditions for the most important European tree species across Europe.

inventory data, diameter growth, growth equations

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15 - Impacts of environmental changes on growth and productivity of managed and unmanaged forests

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1344 **Evaluating future carbon stocks in forests: the importance of stem form**

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Abstract: Both volume and density of each tree compartment are needed to evaluate forest biomass. Changes in wood density with climatic conditions has seen some research. Little work has however been done on studying the shifts in stem volume even if the main stem of tree accounts for up to 70% of its' biomass. A previously published stem taper equation was modified to include climatic variables. Two models (one with annual averages and the other with seasonal averages) were calibrated with data from 8 558 trees from five of the most important species in the province of Quebec (white birch, trembling aspen, balsam fir, white and black spruce). For trembling aspen and white spruce, the best model integrated the annual variables, while the best model for the other species relied on seasonal climatic variables. When calculating tree volume from the taper equations, differences between the volume of a tree with the 10th and 90th percentile of each variable varied between -8% to +7% . Furthermore, when climate change scenarios proposed by the IPCC are used, tree volume fluctuates from -6% for white birch to +6% for balsam fir, which translates to a 3-4% change in biomass if wood density is considered as stable. Shifts in tree form were found to be related to certain species-specific functional traits: for two trees with the same dimensions, trees with higher tolerance to waterlogging and shade were found to have more taper, and thus less volume. These important changes can either enhance or reduce the effects of variations in wood density on biomass estimates. As the temperate and boreal forests contain approximately 1100 stems/ha, a small change in tree volume can have a large impact on future forest yield and carbon stock estimations. Evaluating future forest productivity, biomass and carbon stocks must thus consider both wood density variations as well as shifts in tree shapes.

tree form and taper, global changes, tree biomass

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3590 **Productivity loss expected for Austrian forests in consequence of climate warming**

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Abstract: Radial tree stem growth of Picea abies, Fagus sylvatica and Pinus cembra was monitored in the period from 2012 until 2015 across a broad ecological gradient in Austria by means of high resolution dendrometers. Annual cumulative diameter increment was modeled using a hierarchical nonlinear mixed-effects model (HNLMM) framework based on a logistic growth curve together with a comprehensive set of regressor covariables.
Traditional temperature-based growing season definitions were applied to derive time points for onset, cessation and duration of each growing season. When compared with predictions of conditional expectations by the HNLMM, temperature-based calculations proved to be an imprecise predictor for the actual growing season and can thus serve only as coarse approximation.
The average annual diameter increment of 0.30 cm was lowered by 50 % on lower altitude sites and by 10 % on higher altitude alpine sites in the dry and warm year 2015. In the cool and moist year 2014 Norway spruce achieved higher annual radial increment than European beech, and the opposite occurred in the dry and warm year 2013 and 2015. Beech's consumptive water-use strategy might have caused intensified stress for spruce in drought periods. Consequently, higher benefits from climate warming are rather expected for beech than for spruce.
On higher altitude sites annual increment rates of Norway spruce were more sensitive to climate oscillation compared with stone pine. Because of spruce's higher reaction potential stone pine might be thus out-competed under future climate change.
Productivity differed strongly dependent on the social tree status with dominant and intermediate trees suffering more sever increment reductions with drought. Because warming and drought lowers increment rates on lower altitude sites and as trees on higher altitude sites react less flexible, productivity losses can be expected in summary for Austrian forests in consequence of climate warming.

Intra-annual growth, dendrometer, mixed model

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3178 **Projecting forest productivity under climate change at the European scale: a metamodeling approach**

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Abstract: Climate change is expected to impact forest productivity in Europe, but projections strongly depend on modelling choices, such as climate change scenarios and assumptions regarding the response of tree species to environmental changes, e.g. sensitivity to drought and CO2 fertilisation. Moreover, few studies attempted to achieve European-wide coverage, and synthesising results from different models, methods and case studies is not usually straightforward. A comprehensive picture of the response of forest productivity at the European scale is therefore still lacking. We explored and quantified the response of forest productivity to changes in environmental conditions all over Europe using a modelling approach to upscale from site-specific results. We sampled climatic conditions from a European grid and conducted simulations with the forest model ForClim. We analysed the response of five tree species to variations in environmental variables and derived metamodels of species productivity. Maps of current and future forest productivity under different scenarios showed areas with high vulnerability or expected benefit from climate change. Our approach provides a broad picture of future forest productivity in Europe. The metamodels were also coupled with a land allocation model to simulate the combined impact of land use change, socio-economic and climatic drivers on forests and agriculture.

Forest model, productivity, climate change, Europe

All Division 4 (Forest Assessment, Modelling and Management) Meeting

90 - Advanced Methods for Measuring, Monitoring and Assessing Forests to Meet Societal Challenges

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1579 **A comparison of annual composites versus the full temporal sequence in satellite imagery time series for forest disturbance mapping**

Hislop, S.* (1); Jones, S. (1); Soto-Berelov, M. (1); Haywood, A. (2)

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Abstract: The sustainable management of forests is essential for a range of ecosystem services. Satellite earth observation is a powerful and cost effective means to monitor forest changes over large areas. Pixel-based time-series of Landsat satellite data allows us to develop rich disturbance / recovery histories to assess forest changes over several decades. In this paper, we present a comparison between using representative annual composite images versus using all available images to track disturbance in South East Australian forests. Results indicate that using annual images allows for the quantification of large abrupt disturbances such as wildfire and clear-fell logging to be accurately detected within a year of the event. These techniques also enable longer term trends to be extracted from the temporal trajectory. However, low intensity disturbances are harder to detect via this method. In comparison, using the full temporal sequence reveals more subtle disturbance events, such as fuel reduction burning, insect defoliation and disease. There are a number of trade-offs to using all images, however, including more storage/processing requirements, issues with image noise (bad data), and a tendency to over classify disturbances. Models using all available imagery must also contend with vegetation phenology and changes in sun-angle, confounding correct attribution of disturbance histories.

Pixel-based time-series, satellite imagery

K 5-7 (Konzerthaus Freiburg)

IUFRO17-893 **Fast normalized cross correlation for Araucaria angustifolia detection in canopy height models derived from Aerial Laser Scanning data**

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Abstract: Araucaria angustifolia, also known as Paran á's pine or araucaria, is an important and endangered southern Brazilian softwood tree species. Accurate tools for A. angustifolia trees detection do not exist at the moment to serve as an asset for remotely detect trees in natural environments. Therefore, this study aims to create an algorithm to automatically recognize A. angustifolia from canopy height models (CHM) employing fast normalized cross correlation (FNCC). To achieve this goal, a script was written in python programming language using template matching in order to automatically recognize the A. angustifolia trees. The template matching algorithm uses FNCC to calculate correlation indexes between the original image and a template. When the accuracy threshold is reached, the coordinate of the pixel from this index is registered as the tree location. To validate the algorithm, the trees measured locations were used. Preliminary result indicate that FNCC has potential to automatically recognize adult trees of A. angustifolia, where 89% of the test trees were recognized correctly. However, there is still the occurrence of omission and commission errors, reaching 11% and 4.5%, respectively. Therefore, further investigation is required in order to optimize the errors, especially the commission error.

LiDAR, tree detection, template matching

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3479 **Regional scale simulation of the forest resources evolution in Southern Belgium**

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Abstract: The availability of forest resources is directly affected by forest composition and structure changes that can regularly occur in the context of intensive silviculture and plantation of fast-growing tree species. Since 2000, the total area covered by Norway spruce plantations has decreased by an estimated 25% in Southern Belgium (Wallonia), which is especially worrying as they yield almost half of the total timber volume of the region.
In order to predict the evolution of our forest resources, we first used aerial photographic interpretation to update the data of the permanent regional inventory and provide a more accurate assessment of the current resources of Wallonia. We then developed harmonized distance independent growth and management models for the three most planted softwood species of Wallonia : Norway spruce (Picea abies), Douglas-fir (Pseudotsuga menziensii) and larches (Larix sp.). These models were then implemented in a simulation software that can operate at a regional scale.
This presentation introduces our methodology, the operating of our simulator, our current progress to adapt it for other stand structures and compositions and examples of carried out simulations.

Forest simulation software, Wallonia

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90 - Advanced Methods for Measuring, Monitoring and Assessing Forests to Meet Societal Challenges

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3545 **Long-term trends and patterns of forest disturbance dynamics in Central Europe from Landsat time series**

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(1) Humboldt-University of Berlin, Berlin, Germany; (2) Oregon State University, Corvallis, United States; (3) US Forest Service, Corvallis, United States

Abstract: Forest disturbances from wind, insects, drought, and wildfires have increased in Europe over the last century and are likely to continue to increase in the future. To successfully adapt management and policy to these future challenges will require improved monitoring of forest disturbances and their impacts on ecosystem structure and function. The objective of this study is to map and characterize annual forest disturbance rates and patterns in Central Europe between 1985 and 2015 using medium resolution sensor data from the Landsat satellites. By combining a statistical sample of photo-interpretation plots and trajectory-based change detection we map and distinguish between transient (e.g. defoliator, forest health) and abrupt changes (e.g. bark beetle, harvest, fire). We then analyze the spatial and temporal patterns of forest harvest and natural disturbances, and show how disturbance rates and trends differ between countries and biogeographic regions. The findings will aid the on-going European-wide efforts, in line with the Copernicus Land Monitoring Service, to harmonize and operationalize forest monitoring for climate change mitigation and adaptation, sustainable forest management, and environmental protection.

Remote sensing, Landsat, Disturbances, Europe

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2612 **Plot dimension for continuing forest inventories in the state of Amapá, Eastern Amazon, Brazil**

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Abstract: The objective of this study was to indicate the ideal plot dimension to be used in continuous inventories in the Amazon. The study area is located in the State Forest of Amapá, in the municipality of Porto Grande. The data were obtained from a monitoring inventory carried out on the occasions of 2010, 2012 and 2016 in five permanent plots of 100m x 100m with inclusion level of trees with DBH equal or greater than 10 cm. Within these plots were randomly allocated small plots with five different dimensions varying from 400 to 1600 m2. The time of measurement of each plot were recorded, from the first to the last tree. Forest growth was evaluated from 2010 to 2016, obtaining the estimates of the variables: annual increment in DBH, basal area and volume per plot. The dimensions were analyzed for their accuracy by Relative Efficiency methodology. The rectangular plot of 20m x 40m (800 m2) was the most suitable to evaluate the increments in continuous forest inventories in Amazon, with similar soils, climatic conditions and DBH inclusion level.

Forest dynamics

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2449 **Utility of local and global maps for improving estimates of forest area in north and north-east Armenia.**

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Abstract: The extent and condition of forest ecosystems in Armenia have decreased drastically since the disintegration of the Union of Soviet Socialist Republics in the early 1990s. This decline is not only a consequence of the recent history of the area, but also the result of decades of forest policies and management practices. To reverse the negative trends, it is important for stakeholders, scientists, resource managers and policy makers to have quantifiable information on forest area, yet there is distinct lack of a reliable official national statistics on forest area. This lack of reliable information has been identified as a key challenge in improving the current conditions of the forests and the forestry sector in Armenia. This paper explores the utility of combining local and global forest maps with post-stratified and model-assisted estimators to increase the precision of estimates of forest area in north and north-east Armenia. The post-stratified estimators produced estimates of greater precision than the model-assisted regression estimators for maps of categorical variables, but the model assisted estimators produced estimates of greater precision for maps of continuous variables. The Global Forest Change 2000-2014 map was the least accurate of all the maps, but it produced estimates of forest area that were similar to those for the other maps and that were more precise than if the map had not been used. It is hoped that this approach demonstrates how such processes can be integrated into national forest monitoring and reporting to increase precision and reduce costs.

All Division 4 (Forest Assessment, Modelling and Management) Meeting

36 - Interactions of Global Forest Resources and Climate

K 8 (Konzerthaus Freiburg)

IUFRO17-3036 **The Effect of Technological Change on Forest Carbon Fluxes: Massive Timber Construction and Genetically-enhanced Species**

van Kooten, G. C.* (1)

(1) University of Victoria, Department of Economics, Victoria, BC, Canada

Abstract: Two recent technological developments have the ability to enhance the importance of commercial forestry activities in mitigating climate change - (1) the use of Cross Laminated Timber (CLT) in construction of high-rise and multiple-purpose buildings, which will greatly increase the carbon stored in post-harvest wood product pools; and (2) regeneration of harvested sites with genetically-enhanced (GE) tree species that has the potential to increase greatly the sequestration of CO2 in forest ecosystems while also reducing wood waste during harvest and processing. In this paper, a canonical forest is constructed using information about forests in British Columbia's interior, which currently produces more softwood lumber than any other region in Canada. Expert opinion will be used to determine the potential carbon fluxes associated with GE timber and CTL construction. A forest management LP model is developed to investigate the effect of the GE and CLT technologies on dynamic carbon fluxes. The results are confirmed more generally by comparing the carbon fluxes derived from the integrated forest management model with those from a Faustmann rotation age model that explicitly includes benefits of storing carbon. The outcomes of the research illustrate the importance of carbon prices and, particularly, the urgency of addressing climate change.

climate change mitigation & forestry

K 8 (Konzerthaus Freiburg)

IUFRO17-3079 **Model meets data: Challenges and opportunities to implement land management in Earth system models**

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Abstract: Authors: Julia Pongratz, Han Dolman, Axel Don, Karl-Heinz Erb, Richard Fuchs, Martin Herold, Chris Jones, Sebastiaan Luyssaert, Tobias Kuemmerle, Patrick Meyfroidt, Kim Naudts

Land-based demand for food and fibre is projected to increase in the future. Only part of this increase will be met by expansion of land use into relatively untouched regions. Additional demand will have to be fulfilled by intensification in management of land that already is under agricultural and forestry use. Such land management today occurs on about half of the ice-free land surface. As the number of studies revealing substantial biogeophysical and biogeochemical effects of land management is increasing, moving beyond land cover change towards including management has become a key focus for Earth system (ES) modeling. However, a basis for prioritizing land management activities for implementation in models is lacking.

We lay this basis for prioritization in a collaborative project across the disciplines of ES modeling, land system science, and Earth observation. We first assess status and plans of implementing land management in ES models. We then assess five criteria for prioritizing the implementation of land management activities: (1) spatial extent, (2) evidence for substantial effects on the ES, (3) process understanding, (4) possibility to link the management activity to existing concepts and structures of models, (5) availability of data required as model input. We evaluate ten common management activities for their performance in terms of importance for the ES, possibility of technical implementation in models, and data availability. This synthesis reveals some "low-hanging" fruits for model implementation, but also challenges for the assessment of land management effects. The identified gaps can guide prioritization within the data community from the ES modeling perspective.

land use, land management, climate, modeling

K 8 (Konzerthaus Freiburg)

IUFRO17-2673 **Impact of climate change mitigation on the global woody biomass use in 2010-2100**

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Abstract: In this study we investigate the implications of climate change mitigation on the global woody biomass use in 2010-2100 by applying the Global Biosphere Management Model (GLOBIOM). We show that the higher bioenergy demand needed to reach the 2 °C target can be achieved without significant distortions to woody biomass material use and it can even benefit the forest industry, because the higher demand for forest industry by-products makes material production more profitable. Hence, the climate change mitigation is not a substitute but a complement to woody biomass material use. The 2 °C target increases intensity of forest resources use considerably from 30% to 53% in 2100. Nevertheless, our results show that the target can be achieved by improving the efficiency of forest management in the forests that are already disturbed by human activity, without a need to decrease the amount of primary forests.

climate change mitigation, woody biomass use

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36 - Interactions of Global Forest Resources and Climate

K 8 (Konzerthaus Freiburg)

IUFRO17-2734 **Impact of forest management regimes on forest carbon cycling and other ecosystem processes in Europe**

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Abstract: Dynamic global vegetation models (DGVMs) allow for projection of the climate change mitigation potential of forests, while accounting for many different plant and soil processes as well as their interactions and responses to climate and climate change from local to global scale. Recent studies have demonstrated that accounting for different management options substantially alters the estimated carbon emissions due to land-use and land-cover change. Depending on the management regime and history, forest management has very different impacts on forest state and function. However, despite of most forests being managed, many DGVMs still simulate only processes as they take place in natural forests.
We will present the latest developments of a widely used DGVM called LPJ-GUESS to account for large scale forest management. Thereby, clear-cut and selective harvest is distinguished. Historic and current forest management is simulated based on estimated timber demand as well as species distributions and harvest fractions from forest inventory data. Several possible future harvest intensities and planting scenarios are compared to assess the effect of forest management on above- and belowground carbon storage, timber yield and water fluxes. It will also be explored how management interacts with climate and atmospheric CO2 levels.

global vegetation model, climate change mitigation

K 8 (Konzerthaus Freiburg)

IUFRO17-3930 **Impact of age-dependent harvest in land-surface models**

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(1) Max Planck Institute for Meteorology, Hamburg, Germany

wood harvest, albedo, carbon, climate, forest age

K 8 (Konzerthaus Freiburg)

IUFRO17-3624 **Global Forest Resources Utilization by Adaptining Sustained Yield Harvesting to Future Climate Change**

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Abstract: Forest ecosystems play a major role in up-taking global CO2 emission and affect global climate conditions by up-taking globally 2.4 ± 0.4 PgC per year. However, forest utilizations and interaction of management with large-scale natural disturbances, such as forest fires, may emit tones of CO2 immediately to the atmosphere and act as a source of CO2 emissions. In this study, we investigate the relevance of allowing wood harvest decisions to respond to changes in environmental conditions and apply the concept of "sustained yields" (SY) to illustrate the consequences of representing adaptive forest management in a dynamic global vegetation model "JSBACH", the land component of the Max-Planck-Institute's Earth System Model. We compare SY rule with the RCPs prescribed wood harvest maps for 21st century to analyze differences in the amount of harvested wood materials and their decay over time and carbon losses due to disturbances and background mortality. Both SY and RCPs harvest rules were forced by RCPs climate and CO2 concentration from CMIP5 dataset. Results show that SY could successfully keep the above-ground forest carbon stock unchanged and realize a large harvest potential of 3.2-8 PgC per year versus RCPS with 1-2.2 PgC per year. These accounts for about 420 to 610 PgC cumulatively until 2100 for SY and 130 to 210 PgC for RCPs. Mitigation effects of both rules has been analyzed considering harvested materials decay in their life time and the change in atmospheric CO2. SY realizes a mitigation effect of 124- 140 PgC storage in anthropogenic wood products pools in the middle of 21st century, whereby, RCPs mitigate 38-51 PgC. This amount increases to 255-380 PgC for SY and 85-132 for RCPs until the end of 21st century.

Wood decay; Harvest rule; Climate scenario; RCPs

All Division 4 (Forest Assessment, Modelling and Management) Meeting

90 - Advanced Methods for Measuring, Monitoring and Assessing Forests to Meet Societal Challenges

K 5-7 (Konzerthaus Freiburg)

IUFRO17-215 **Forest Observational Studies - an Essential National Green Infrastructure for measuring & monitoring forest ecosystem dynamics and climate change impacts**

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Abstract: Natural forests, whether managed or unmanaged, exhibit complex structures and changing spatial patterns, and a designed planting of species mixtures cannot mimic the complexity resulting from local variation of tree species, ages & dimensions, and the varying spatial arrangement of these attributes. Long-term Forest Observational Studies (FOS) usually provide a comprehensive data pool useful for a great variety of research interests such as modelling ecosystem structure and dynamics. They may occasionally complement National Forest Inventories. However, the primary objective is improved understanding of forest ecosystems.
This contribution clarifies the definition and purpose of Forest Observational Studies and provides background and context for their installation, maintenance and application. We also present examples of forest observational networks and provide evidence to show that such networks represent an important "green infrastructure" which is essential for the sustainable use of forests that exhibit complex structures and a diversity of tree species and tree dimensions. Specifically, this contribution clarifies the differences between National Forest Inventories and Forest Observational Studies, between Manipulated Experiments and Observational Studies, and between Longitudinal, Cross-Sectional and Interval Studies; presents examples of new Forest Observational Studies, and highlights the new focus of such studies compared to traditional forest growth plots; and shows how specific information gathered in Forest Observational Studies can be used to simplify complex ecosystems with the aim of maintaining natural structures and natural ecosystem functions in response to human use.
Finally, we emphasize the importance of institutional commitment for maintaining long-term field studies and summarize the potential of such installations for analysing and modeling forest ecosystems within networks of interdisciplinary research.

Ecosystem, Structure, Diversity, FOS, monitoring

K 5-7 (Konzerthaus Freiburg)

IUFRO17-856 **Balancing timber mobilization and biodiversity conservation in mixed broadleaf-conifer forests: an inventory-based scenario analysis**

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Abstract: Timber use in Central Europe is expected to increase and forest policy makers seek to strengthen local wood supplies for energy production, construction and other uses. Such a policy may conflict with the sustainability of timber production, conservation and other ecosystem services. We developed a diverse set of forest management scenarios to drive the inventory-based forest simulator MASSIMO for the Swiss canton of Aargau for 100 years starting in 2006 (3rd National Forest Inventory). Growing stock dropped from 346 m3 ha-1 to 192 m3 ha-1 in 2106 if observed timber harvesting was to be continued. Long-term increment and harvests decreased under this and alternative scenarios that reduced growing stocks. However, a scenario that favored conifers resulted in increased harvest because conifers grew faster than broadleaves. Retaining habitat trees to benefit biodiversity reduced harvests (0.055 m3 ha-1 yr-1 per habitat tree) and increased harvesting costs. We discuss favoring conifers under climate change and the opportunities and threats of promoting energy wood and habitat trees for future timber harvesting. In conclusion we find that even short-term (1-2 decades) increases in timber mobilization trade-off with future forest productivity and that they need to be carefully balanced with other forest ecosystem services.

modelling, inventory, habitat tree, timber

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3052 **Multipurpose long term monitoring study on thinning intensity of major coniferous plantations in the Republic of Korea**

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Abstract: Multipurpose long term monitoring is required for analysis and comprehension of spatial and temporal dynamics of forest as well as site characteristics by thinning practices. Focusing on major coniferous planting species in the Republic of Korea permanent monitoring plots were installed in 38 sites of Pinus densiflora(Pd), 45 sites of Pinus koraiensis(Pk) and 45 sites of Larix kaempferi(Lk) from 2012~2015. Each plot consists three square plots for non-thinning(C), light thinning(L) and high thinning(H) with the size of 20 m × 20 m, 25 m × 25 m, and 30 m × 30 m, respectively. We removed 20% and 40% of total basal area from low intensity thinning and high intensity thinning plots. The multipurpose monitoring is conducted focusing on 1) measurement & inventory (DBH, height, crown width, crown class, stem quality, tree coordinate), 2) forest micro-climate(temperature, humidity, illumination and wind velocity), 3) GIS/RS(forest spatial analysis and DB construction), 4) wood use (wood density, compressive strength and section structure), 5) soil (chemical & physical property, organic matter) and 6) others(biodiversity, biomass and carbon stock). The plots will be inventoried every 3 years and it is expected to play a key role in the long-term monitoring for understanding the dynamics of forest and site characteristics according to thinning intensity.

monitoring, thinning, coniferous, plot, basal area

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90 - Advanced Methods for Measuring, Monitoring and Assessing Forests to Meet Societal Challenges

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3284 **Combined usage of Terrestrial Laser Scanner (TLS) and Drone as an effective tool for forest parameters extraction**

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Abstract: Accurate measures in forest inventories are crucial. Though manual measurements are precise, they are time consuming, while most of the times, the amount of collected data is limited in DBH and Height.
Contemporary technological achievements such as TLS and Drones can be used in forest inventories, where capturing detailed and highly accurate information, such as geometry, texture or color, can be obtained in great speed.
This study is focusing on automatic tree and tree crown parameters extraction from different combinations of acquired TLS and Drone Point Cloud (PC-)datasets, on a plot level. The plot is located at the suburban forest "Seih Sou" in Thessaloniki, Greece, due to its great impact on the local community, as the most essential forest lung and recreation area of Thessaloniki.
The main objective is the accuracy and efficiency checks on PC-datasets combinations in order to define the most appropriate dataset compared to manual measurements. The forest parameters that were measured are: Position, DBH, Height, Stem Curve, Crown bottom Height and Crown Height, while the tested combinations are: a. Multi TLS vs Drone, b. Multi TLS / Drone vs multi TLS, c. Single TLS vs Drone and d. Single TLS / Drone vs Single TLS.

TLS, Drone, forest inventories, DBH, Height

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3666 **Measuring canopy cover, upper layer tree crowns and determining canopy gaps' properties with UAV in "Izvoarele Nerei" Reserve, Romania**

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Abstract: The forest canopy cover as the proportion of the ground covered by the vertical projection of the tree crowns, known as the crown cover represents an important part of forest inventories. The canopy cover is important when analyzing different habitats, microclimates or light conditions. Forest gaps have an important role, especially for the regeneration and for the biodiversity. We measured representative plot areas in terms of canopy cover, tree crowns from the upper layer and canopy gaps using an Unmanned Aerial Vehicle (UAV) in one of the largest pure beech virgin forest in Europe - "Izvoarele Nerei" Nature Reserve, with an area of over 5000 hectares.
The results represent structural determinations such as: canopy cover percentage, number and sizes of upper layer trees, number and properties of canopy gaps, spatial distribution of trees and canopy gaps. The implications and potential advantages of methodology used in current study for further major analysis such as: spatial-temporal dynamics of forest, biodiversity assessment, comparison with other managed/unmanaged forests etc. versus traditional ground-based measuring methods are discussed.

UAV, remote sensing, canopy cover, virgin forest

All Division 4 (Forest Assessment, Modelling and Management) Meeting

197 - Ecosystem services and the well-being of forest-dependent communities: enhancing social

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3911 **Assessing social innovation and its impacts in forest dependent communities: a preliminary methodological framework**

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Abstract: Forest-dependent communities in remote rural areas face challenges such as delocalization of industry and loss of economic activities (only partially stemmed by tourism), ageing, migration, increasing poverty and global environmental change. The EU has increasingly embraced social innovation as a mean for addressing these challenges and rebuilding resilience. However, it is not yet clear how social innovation is defined, how best to support these emergent processes, and how to evaluate them in terms of enhanced well-being. Recognized methodologies for assessing performance and standard units of analysis for evaluation have not been developed yet. This qualitative paper is based on initial analysis carried out within the 4-years EU funded Horizon2020 project Social Innovation in Marginalised Rural Areas (SIMRA). The aims of this paper are to: i) show elements and drivers which support and constrain the emergence of social innovation in forest-related community; and ii) present a preliminary methodological framework and set of possible indicators which can be adopted for assessing social innovation in these initiatives. Preliminary results show that assessment of social innovation requires a suite of qualitative and quantitative methods and indicators, a combination of expert and participatory-based approaches capturing both processes and outcomes, as well as primary data from community-based initiatives.

social innovation, indicators, assessment, Europe

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3309 **Integrating of Forest Ecosystem Services into Climate Change Adaptation Plan: A Case Study of Nepal**

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Abstract: Climate Change Adaptation (CCA) approaches are increasing being seen to be more and more important to community based forest management process in Nepal. The Community based climate change adaptation plan of action (CAPA) groups are formed as a grassroots initiative at the level of community forest user groups (CFUGs) which links ecosystem integrity, ecosystem services and social well-being. The study has aimed to assess the vulnerability of forest ecosystem service provision and efficient measures for natural restoration and ecological engineering for local adaptation plan.Participatory qualitative tools such as focus group discussion, key informant interviews, stakeholder consultation, and direct observation were employed in 12 CAPAs groups as representative of three geo-graphical regions of Nepal. The results categorized first how CAPAs groups are evaluating the likelihood of climate change impact and feeling the vulnerability of the specific ecosystem services under predicted climate change and second how they are understanding the possible local adaptation measures in their areas. The study also brought information about the ecosystem service trade-off consciousness and alternative options of local innovation for adaptation. The findings shown that CAPAs groups are aware of adaptive forces of forest ecosystems, included in local adaptation plan, but in confrontation with many ecosystem function disturbances by human activities, the identification of major ecosystem services and advancement of efficient adaptation measures in the CAPA process are lacking by concerned stakeholders. The important adaptation options, problems with their trade-off and sustainable policy measures on biodiversity management are described. The economic analysis of different ecosystem based adaptation options; sustainable policy measures and sector specific adaptation measures are therefore needed while strengthening of institutional arrangement at implementation level in Nepal.

Adaptation, Ecosystem services, Trade-off, Nepal

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2020 **Can Carbon Offset Trading Promote Economic Development in Rural Communities?**

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Abstract: Rural communities across Canada are dependent on the forest industry; some are reliant on forestry for more than 50% of household income. Since 2000, the forest industry has been on a downward trend due to declining demand for lumber and newsprint, led to thousands of layoffs in the logging and processing sectors. As forests play an increasingly pivotal role in climate mitigation, forest-dependent communities face an uncertain future. Will climate policies favour forest conservation, or biofuels and biomaterials?
This paper investigates forestry's role in mitigating climate change. The price of carbon offset credits is used to incentivize lower CO2 emissions and an increase in sequestration of carbon through forestry activities. Forestland owners have two options for creating carbon offset credits: (1) avoid or delay harvest of mature timber, thereby harming rural, forest-dependent communities; or (2) harvest timber and allow natural regeneration or reforestation, storing carbon in post-harvest products, and using sawmill and logging residues to generate electricity, thereby aiding forest communities.
A forest management model is developed to maximize net discounted returns to commercial timber operations plus the benefits of managing carbon fluxes; carbon in living trees, organic matter and post-harvest carbon pools, plus avoided emissions from substituting wood for non-wood in construction or bioenergy for fossil fuels, are tracked. Constraints ensure that forest management is sustainable, while carbon prices ensure efficient mitigation of climate change. The research finds that forest-dependent rural communities can benefit greatly when the price of carbon offset credits is used to incentivize lower CO2 emissions and increase sequestration of carbon through forestry activities. Compared to forest conservation, commercial logging and post-harvest use of wood can create upwards of 144.5 tCO2 carbon offset credits/ha, a potentially large benefit to rural communities.

carbon offsets; climate change; biomass energy

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K 2-4 (Konzerthaus Freiburg)

IUFRO17-610 **Identifying Green Energy Options for the Ukrainian Carpathians**

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Abstract: Apart from climate policies, the anticipated depletion of fossil fuels and geo-political conflicts stir nations to advance the energy transition. The Ukraine, one of the most energy intensive countries, relies strongly on fossil fuels and nuclear energy. Despite having ample energy resources, these cover only half of the country's energy needs. On this background, renewables gain importance. As outlined in the National Renewable Energy Master Plan, biomass could contribute 4.6% to the primary energy consumption in 2030.
At the regional scale, particularly in the Ukrainian Carpathians, energy wood is the most prominent bioenergy source, so far widely used for the provision of heat for households and public infrastructure. In stark contrast to the steadily increasing forest area and volume in this region during the last 50 years, economically accessible volumes of forest residues for energy provision are lacking in many areas. This may be due to the absence of a wood processing industry, a lack of forest road-network and machinery, and other institutional access limits to forests and the forest sector. At the same time local communities are suffering energy scarcity and have to cope with high energy costs. Also, inefficient combustion technologies and poor insulations are widespread.
This 4-years action research project targets at an understanding of the wood related energy system from a biophysical and socioeconomic perspective. With an inter- and transdisciplinary system analysis it focuses on rural communities in two Carpathian Oblasts: Transcarpathia and Iwano Frankiwsk. It aims at assessing the significance and future potential of energy wood and its efficient use for the regional economies and consumer households, including municipalities from an environmental, economic and social perspective. In this paper, the process and results of the refined research design developed with stakeholders and end users during the initial workshop in early 2017 will be presented.

Energy Transition, Energy Wood, Forest ES, Ukraine

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1092 **Building capacities for sustainability of local communities in marginalized rural areas: lessons learnt in the Ukraine's Carpathians and Scotland's uplands**

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Abstract: In this paper, we explore institutional capabilities and practical issues of the contribution of non-wood forest products and services (NWFP&S) to sustainable development of remote mountain areas. Literature review formed the starting phase of this research. We then applied participatory techniques combined with mixed methods to test the hypotheses concerning similarities/differences between the contribution of NWFP&S to the rural communities' well-being in Scottish uplands and the Ukraine's Carpathians. Findings indicate that NWFP&S are generally considered to be important for communities living in marginalised rural areas, such as mountains, where local well-being is usually lower than in other, more accessible and socially and economically advanced regions. In the Carpathians, forest-depended communities heavily rely on forest products and amenities, and are dependent upon the supporting ecosystem services of trees. Forest also contributes to the sense of identity of many community members. In Scotland, to compare with Ukraine, the resource base of NWFPs is relatively small and forest management seldom takes NWFPs into account. The observed in both regions challenges include of how to attain a proper balance between NWFP and wood production, as economically timber remains very important. We conclude that priorities and concerns of forest dependent communities, in term of multiple ecosystem services, need to be identified and included into forest management planning. All relevant stakeholders are to be involved in the decision-making to build resilience and enhance sustainability of remote mountain localities. Commercialization and value-added processing of NWFP should be explored to raise the household income; while sustainable harvesting of NWFP could be enhanced through ecotourism. It is also important to increase environmental awareness and strive for social cohesion with the promotion of social innovation in marginalised rural areas.

well-being, non-wood forest products and services

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2050 **Social Innovation: key for forest recreation infrastructure provisioning?**

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Abstract: Forests in Europe are multifunctional and provide a range of ecosystem services, one of which is outdoor recreation. Additionally, in some countries (e.g. Switzerland) infrastructure for recreation activities (e.g. mountain-bike trails) is also provided. However, the provision of this infrastructure is not obligatory and poses challenges to forest managers and owners. The challenges include liability and cost issues, potential conflicts etc. The infrastructure for recreation is not only provided by forest owners and managers. It is also provided through social innovation in peri-urban and rural areas. However, the role of social innovation in provisioning and securing of forest recreation infrastructure has not been investigated. Social innovation can be seen as 'new ideas that address unmet social needs - and that work' (Mulgan et al., 2007, p. 2). Some scholars in the field of social innovation either focus on new social processes or new social outputs and outcomes. Our research addresses social processes resulting in the development of recreational infrastructure to answer the question: Which actors are involved and how?. Thus, to promote social innovation in forestry and specifically in forest recreation provisioning, in this article, we analyse social innovation from a governance perspective (Ostrom 2011). We center on four mountain-bike trail cases located in the peri-urban and rural areas of Switzerland so as to examine the role social innovation in the provisioning of recreation infrastructure and to analyse the effect it has on forestry (e.g. by increasing the economy of forest recreation). The research is based on several empirical sources including semi-structured interviews The findings suggest that social innovation plays a crucial role in the provisioning of recreation infrastructure and that it can be seen as a way to counterbalance the high costs that forest owners and managers have to pay for its provisioning.

Social Innovation, forest recreation, Switzerland

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K 2-4 (Konzerthaus Freiburg)

IUFRO17-1040 **Assessing forest policy options through an improved understanding of the attitudes prevailing in forest-dependent communities and building resilience in the Ukraine's Carpathians**

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(1) Ukrainian national forestry university, Lviv, Ukraine; (2) The James Hutton Institute, Aberdeen, United Kingdom; (3) Environmental Network Limited, , Aberdeen, United Kingdom

Abstract: Abstract
This paper addresses consultation with representatives of forest-dependent communities in the Ukraine's Carpathians in order to assess forest policy alternatives and develop understanding of the values and preferences held by local people concerning forestry development in remote rural areas. While public attitudes both affect and reflect policy decisions to empirically determine the inter-linkages has been difficult. The current paper develops and applies a socio-economic deliberative support tool based on Q methodology to better understand public attitudes in order to assist in the decision-making. The use of Q-method offers a potentially useful contribution to the assessment of forest policy options as it helps to elucidate a range of attitudes and the spectrum of sustainability to which they may relate. When, as concerning forestry changes, input from communities is important, the applied technique is unique, since its results are driven by the public, but all at once they are systematic and scientifically rigorous. Important criteria of respondents' perspectives have been identified and key factors influencing the attitudinal diversity explained. The paper has put forward some innovative perspectives on the areas of consensus and conflict between people. Despite at times the opposite attitudes towards the future of mountain forestry, all identified attitudinal groups have a strong emphasis on woodlands regeneration. The attention is being paid to the conservation of biodiversity and landscape's beauty, forest multi-functionality, attracting tourists in remote rural areas and woodland development to increase the well-being of local communities. To conclude, the results of this study signify the necessity of building resilience in the Ukraine's Carpathians through the promotion of a more sustainable management of forest multiple ecosystem services as offering a wide range of benefits to the rural communities, environment, and the economy.

All Division 4 (Forest Assessment, Modelling and Management) Meeting

29 - Integrating climate change, disturbances and diversity effects into growth models: from understanding

K9 (Konzerthaus Freiburg)

IUFRO17-2049 **Tree allometric relationships for structurally and species diverse forests**

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Abstract: Allometric relationships are often required in forest growth models and to quantify the effects of biodiversity or stand structural characteristics on forest growth and functioning. However, many of the available relationships were developed in monocultures, or they are general relationships developed after combining data from different treatments. This can lead to severely biased predictions and conclusions. The aim of this study was to examine how commonly used relationships between stem diameter and biomass (e.g. foliage, stem or root), height or crown dimensions are modified by vertical structure (dominance), stand density or species composition. The analysis included a meta-analysis of nearly 1000 published biomass equations for major European tree species. All stand structural variables significantly influenced the relationships, but their effects differed widely between the target species. The inter-specific variability was often correlated with species traits (wood density, shade tolerance). With this information, single "general" equations were developed for each given species that could be applied in any stand structure and species combination. This approach could greatly improve predictions of biomass and carbon stocks in structurally and compositionally diverse forests.

biodiversity, biomass allocation, stand structure

K9 (Konzerthaus Freiburg)

IUFRO17-2126 **Effects of Diversity and Competition on Individual Tree Growth and Productivity Evidence from two Species-rich Afrotemperate Forests**

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Abstract: The warm-temperate African forests are species rich and multi-layered, representing a true challenge to understanding and modelling forest community structure and dynamics. However, the structural complexity of those forests also provides a unique chance to improve our understanding of underlying growth processes in order to improve the often oversimplified modelling approaches designed for less complex ecosystems.
We present results of several decades of research on Afrotemperate and Northern Mistbelt forests, including an observational study with mapped trees, which has been continuously re-measured since 1972. There is evidence to show to what degree species and structural biodiversity impact on standing biomass and biomass productivity by studying the relationship between diversity, standing volume, increment and certain characteristics of forest community structure. The influence of species diversity on standing biomass was significant.
The study shows species-specific sensitivity to competition. Individual trees change their sensitivity to competition from crowding (edaphic competition) and overtopping (light competition) during their lifetime according to their social status and their presence within particular vertical layers (under canopy, canopy, emergent). These findings may guide us on how we should model competition in empirical tree growth simulations. Using merely one index as is often done, might not be sufficient to explain the complex changes between edaphic and light competition in the different growth phases of a tree. We propose adaptation and refinement of the current growth modelling approaches in complex multi-species forests to include model sensitivity to climate and competition effects using a combination of indices.

mixed forests, resource limitation

K9 (Konzerthaus Freiburg)

IUFRO17-3860 **Modelling the growth and yield of mixed-species stands with the Tree and Stand Simulator (TASS)**

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(1) B.C. Ministry of Forests, Lands and Nat.l Res. Operations, Forest Analysis and Inventory Branch, Victoria, Canada; (2) Azura Formetrics Ltd., Kamloops, Canada

Abstract: The Tree and Stand Simulator (TASS) is the primary simulation model used to project the growth and value of managed forests in British Columbia, Canada, for timber supply analysis and silviculture decision support. A complex, individual-tree model that tracks tree crowns in three spatial dimensions, TASS has a flexible structure amenable to adaptation for complicated species mixes and stand structures. In response to management trends favouring greater stand-level diversity, the most recent work (TASS III) has adapted the simulator for high priority conifer species combinations in B.C.--interior lodgepole pine with white spruce, and coastal Douglas-fir with western hemlock. Modelling of within-canopy light has been incorporated and components governing height growth, crown rise and mortality of individual trees are now responsive to light levels. Data for evaluating the predictions of mixed-species dynamics and yields are rare, however. We rely heavily on a few mixed-species experiments and on creative use of permanent sample plots with mixed species. This presentation will emphasize the validation process and the resulting growth and yield predictions for mixed-species stands from B.C. TASS III software is available for PC computing platforms, and predicts cubic volume, biomass, carbon, log and lumber yields, and performs financial analysis to guide stand-level investment decisions.

individual-tree spatial model, light modelling

All Division 4 (Forest Assessment, Modelling and Management) Meeting

29 - Integrating climate change, disturbances and diversity effects into growth models: from understanding

K9 (Konzerthaus Freiburg)

IUFRO17-105 **A copula-based stochastic individual tree growth model for mixed species Acadian Forests**

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Abstract: An innovative approach to modeling individual tree growth and development based on nearest neighbor imputation and copula sampling is presented. The model uses individual tree records from approximately 20,000 permanent sample plots collected throughout northeastern North America. A tree list structure similar tothe tree list structure required by FVS variants is used as the input and a combination of nearest neighbor imputation and copula sampling is used to predict tree and plot development based on the 2.7 million individual tree records database. Methods of incorporating climatic effects are explored. The model is simultaneously run multiple times and projection bounds are developed at both the individual tree and plot levels. The model can be used to derived prediction certainties and to explore risk analyses in long-term management. A general framework for how the model can be adapted to any permanent sample database is presented.

stochastic tree model, copulas, imputation

K9 (Konzerthaus Freiburg)

IUFRO17-1215 **Scenario analyses of the transition to close-to-nature mountain forest management from the perspective of climate change**

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Abstract: Climate trends and drought events pose a particularly significant threat to forests, specifically those in mountain regions. From silvicultural point of view forest transition to mixed, uneven-aged, and continuously covered stands may stabilize mountain forests and ensure their valuable ecosystem services even in a changing climate. It will be shown how a transition to close-to-nature mountain forests in the German Alps is supported by model based scenario analyses.
We show how the climate-sensitive individual tree simulator SILVA has been complemented by modules for stand regeneration (planting and natural regeneration), silvicultural treatments (e.g., gap and slot cutting, shelter and femel coup cutting), and stand opening (e.g., cable crane and rack lines). Typical initial stands were constructed based on forest inventory data. In order to include the regeneration phase being the most decisive phase for silivicultural treatment the scenario simulations covered time spans of 150 years.
The results were compared and evaluated in terms of stand productivity, structural heterogeneity, stability and economic impact. The outcomes allow a differentiated assessment of silvicultural options in these highly complex forests and underline the usefulness of a spatial explicit single tree based modeling approach for forest practice.

modelling close-to-nature silviculture; conversion

K9 (Konzerthaus Freiburg)

IUFRO17-1032 **Stability of tree increment to episodic drought in uneven-aged, mixed stands**

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Abstract: Future increases in temperature and changes in the water cycle may negatively affect the growth performance of economically important species such as Norway spruce, traditionally managed in monocultures. Recent studies have shown that mixing tree species does not generally reduce water stress to individual species. Whether structural diversity, which is also advocated as a silvicultural approach to increase the resistance and resilience of forests to climate change extremes, has similar effects has not been analyzed yet.
We investigated tree-ring growth reactions in Norway spruce and Silver fir to mild-to-extreme droughts in 28 stands in southwestern Germany, which display a gradient of structural and species diversity. We modeled resistance, recovery and resilience of diameter increment as indicators of growth stability using a mixed-effects framework as a function of species, drought intensity, tree size, thinning intensity, and diversity in species and structure.
Silver fir proved more resistant and resilient than spruce, yet showed slightly lower recovery following drought years. Resistance and resilience decreased with increasing tree size. Thinning increased the stability of tree-ring growth, whereas higher drought stress reduced it. For both species, diversity in species or structure reduced resistance, increased recovery, but had no effect on resilience.
Our study indicates that Silver fir is more tolerant to drought stress than Norway spruce and confirms its potential as a silvicultural alternative to spruce under climate change. Structural diversity appears to have a similar influence on the temporal stability of tree-ring growth as species diversity.

increment diversity drought resilience tree-rings

All Division 4 (Forest Assessment, Modelling and Management) Meeting

29 - Integrating climate change, disturbances and diversity effects into growth models: from understanding

K9 (Konzerthaus Freiburg)

IUFRO17-1051 **Predicting future harvesting potential in Switzerland: evaluation of a new climate-sensitive growth function in the scenario model Massimo**

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(1) Swiss Federal Institute WSL , Birmensdorf, Switzerland

Abstract: Individual-tree growth simulators are a useful tool to predict growth and yield, as they allow for statistically representative estimations. Such models are applicable for monospecific and mixed stands under varying management regimes and, with appropriate consideration of demographic processes, climate change. The ***Ma****nagement* ***S****cenario* ***S****imulation* ***Mo****del* Massimo is an empirical individual-tree growth simulator that is linked to the sample plots of the Swiss NFI. Massimo consists of the sub-models growth, losses (i.e. disturbance, harvesting and mortality) and regeneration. We implemented a new climate-sensitive growth function and evaluated it against the function used so far. We simulated a standard scenario with constant growing stock targets for one century and compared the old function and the new, climate-sensitive growth function. We assessed the effects of both functions on forest growth under three variants of the A1B climate scenario (ECHAM5/CLM: hot and dry, ECHAM5/RCA: warm and dry, ECHAM5/REGCM3: cool and humid). While most tree species benefited from increased temperature, their growth was negatively influenced by increasing drought. Nevertheless, simulations resulted in generally increased gross growth. We conclude that Swiss harvesting potentials may increase overall in future, however, with strong regional deviations.

growth simulator; Massimo; climate-sensitivity

All Division 4 (Forest Assessment, Modelling and Management) Meeting

197 - Ecosystem services and the well-being of forest-dependent communities: enhancing social

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1360 **Social innovation in the Welsh Woodlands: the case of community efforts in woodland-based Third-Sector engagement**

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Abstract: The term "Third Sector" is an umbrella term for all organisations working with civil society in a not-for-profit capacity, differentiating them from the public (First) and the private (Second) sector. Sometimes it is also referred to as the "civil sector". The paper sets out to examine the specific challenges and success factors of two specific community centres located in the Welsh Woodlands: The Woodlands Skill Centre and the Coppice Wood College. They are both social innovations as their activities are motivated by the goal of meeting a social need and are developed and diffused through organisations whose primary purposes are social (Mulgan et al. 2007). Despite many differences in their ways of inclusion and participation of stakeholders as well in their communal approach towards the organisational level, both projects have reached successful levels of rural empowerment and bringing livelihood and income to the area. Both initiatives are long term projects with complex governance structures, but different ownership structures and a different marketing of the services and goods they provide. The research insights contribute with two empirical examples to insights about social innovation in rural areas, namely their "secrets of success" in procedural determinants of origin and support factors.

Ecosystem services Wales LEADER communal services

K 2-4 (Konzerthaus Freiburg)

IUFRO17-4086 **Social innovation, forest ecosystem services and sustainable agriculture: tensions and synergies around the valorisation of Guadeloupean forest (FWI)**

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Abstract: Sustainable use of forest ecosystem services could provide substantial contribution to the well-being of forest-dependent communities but still, the vision of forests as a resource generate conflicts between stakeholders with diverging views. Based on the literature, we elaborate a conceptual model of the interrelations between the social and the ecological system and of the role of social innovation in the delivering of forest ecosystem services and sustainable agriculture. We apply our analysis to a Guadeloupean case study (FWI) where farmers have just initiated a project with the aim to achieve the simultaneous objective of enhancing their agricultural and forest based livelihoods while maintaining the provision of ecosystem services of the forest. Using semi-structured interviews of key representatives of different stakeholders' group we then confront this model with stakeholders' vision and perception of the forest and examine the role of social innovation as well as its potential impact on the delivering of an integrated valorisation of the forest. We present here the preliminary results of this work. Future prospects imply the use of this model and participatory planning tools to help stakeholders build up a common representation of the services forest and agriculture can deliver together and create synergies among them.

Socio-ecological system model, social innovation

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1011 **Benefits and Perceptions of Forests: The Case of Rural People in Bago Yoma, Myanmar**

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Abstract: Most of indigenous people in Myanmar live in or around the forest depending upon forest resources for their subsistence and generating side income. This study analyzes the economic and environmental contribution of forest resources to rural community in Bago Yoma, South-Central Myanmar, aiming at understanding their perceptions of benefits from the forest. Income accounting, income diversification and NTFPs dependency were calculated to know share of income from NTFPs in total household income between agricultural land owners and landless. Environmental benefits from the forest getting by the households, their willingness to participate in conservation activities and awareness of deforestation were examined by ranking the scenarios of drivers of deforestation. Income from NTFPs has the highest positive effect on landless households' total income among different income sources. Regulating local weather is the environmental benefit that rural households received from the forests most. Households have more willingness to participate in forest conservation activities if there is alternative income opportunities. As the extraction of NTFPs can provide main income from the forest, it is challenging the protection of forests. Therefore, sustainable forest management should take into consideration the understanding of interaction between forest and rural communities by formulating rural livelihoods strategies.

Forest, people's perceptions, complex interaction

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197 - Ecosystem services and the well-being of forest-dependent communities: enhancing social

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3267 **Biodiversity and ecosystem services in a rural to urban forested watershed near Mexico City**

Avila-Akerberg, V.* (1); Gonzalez-Martinez, T. (1); Lopez-Mathamba, L. A. (1)

(1) Institute for Agricultural and Rural Sciences, Autonomous University of the State of Mexico, Toluca, Mexico

Abstract: The territory of Guadalupe dam watershed (GDW) is located in the central part of Mexico, abutting Mexico City in its lowest parts. With a high altitudinal interval (2200-3870 m asl), a medium catchment size (38,000 hectares) and a high population (ca. 1,5 million inhabitants), it has a unique natural beauty in the higher parts with many water bodies and crystal clear streams, vast and well-preserved vegetation cover and forests of oaks, firs and pines, together with some productive activities like potatoe and wheat agriculture, extensive livestock breeding, trout farming, silviculture and ecotourism. Biodiversity is fairly high, with an estimate of 1,600 species, mainly plants, animals and fungi, many of which are endemic. At medium altitudes semi rural villages appear, with traditional maize croplands, intensive greenhouse agriculture and most of the population activities related to the tertiary sector: services and commerce. In the lowest areas of the region, it is mainly a densely populated urban area with circa 90% of the people living inside GDW in which contrasting living standards make different uses of the land. Governance is complex with local communities and "ejidos" at the first level, together with municipalities; state and national regulations underline general. Currently the territory of GDW has an important social and economic backwardness due to the lack of jobs and low levels of education, which has resulted in increasing levels of migration to larger cities and the United States. Based on this problem our research intends to promote local development strategies from a better understanding of land use, biodiversity and ecosystem services provision and valuation, together with local environmental education in order to improve the living conditions of the people and strengthen their social capital.

ES valuation, environmental education, landscape

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29 - Integrating climate change, disturbances and diversity effects into growth models: from understanding

K9 (Konzerthaus Freiburg)

IUFRO17-3244 **Addressing the Confounding Effect of Insect Disturbance when Assessing Growth in Mixed Species Stands Following Pre-commercial Thinning**

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Abstract: An experiment to assess the impact of pre-commercial thinning on the growth dynamics of naturally-established stands in the central interior of British Columbia, Canada was installed in 1990. Three thinning treatments and a control were employed within each of three blocks. Two plots were located in each block-treatment combination for a total of 24 plots. The plots have subsequently been measured on 5 occasions. The selected stands, although dominated by interior Douglas-fir (Pseudotsuga menziesii var. glauca), included varying amounts of several other species including lodgepole pine (Pinus contorta). Much of the lodgepole pine originally growing in the plots were killed by the Mountain Pine Beetle (Dendroctonus ponderosae) in the mid-2000s. Lodgepole pine trees were distributed unevenly among the plots located in the different blocks and treatments and their subsequent mortality confounds the straightforward assessment of response to the thinning treatments. This presentation compares the results of several approaches used to circumvent the impact of the disturbance when assessing the impact of the various thinning treatments on the subsequent dynamics of these stands and concludes that an appropriately-specified mixed effects model can effectively assess the tree growth response to the thinning treatments despite the confounding impact of the disturbance.

Interior Douglas-fir, Mountain Pine Beetle

K9 (Konzerthaus Freiburg)

IUFRO17-1496 **Integrating effects of diversity, disturbances, and climate change into forest landscape modeling**

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Abstract: Recent environmental and societal developments pose new challenges for the prediction of forest growth and yield. The need to incorporate climate change and simulate non-analog future conditions calls for an increasing application of process based approaches. Furthermore, recent findings on significant diversity effects on productivity suggest that a detailed representation of mixed forests is needed to simulate tree growth. Also, a growing importance of landscape processes such as disturbances suggests that scaling up beyond the stand scale is increasingly needed. We here present the individual-based forest landscape and disturbance model iLand as one possible means to address these challenges. The model simulates competition for resources on the level of individual trees and is thus able to simulate the effects of tree species mixtures mechanistically. Net primary production is estimated using a light-use-efficiency approach that is sensitive to changes in climatic drivers. The model explicitly simulates forest landscapes up to several thousand hectares, considering landscape level processes such as tree migration and disturbance by fires, wind, and bark beetles. We here present tests of the models ability to predict forest growth, comparing simulations against independent data from thinning trials. Subsequently, we analyze the effect of tree species diversity on productivity, and its interaction with disturbance impacts. Finally, we show how climate change alters disturbances and productivity in a mountain forest landscapes of the Austrian Alps.

iLand, landscape modeling, climate change

K9 (Konzerthaus Freiburg)

IUFRO17-2442 **Development of simulation framework WINDROT for prediction of damages caused by root rot, wind disturbance and European spruce bark beetle**

Honkaniemi, J.* (1); Piri, T. (1); Peltola, H. (2); Heliövaara, K. (3); Ojansuu, R. (1); Lehtonen, M. (1); Hynynen, J. (1); Kasanen, R. (3)

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Abstract: The projected climate change is expected to increase the risk of various disturbances in the boreal forests of northern Europe. The major risks threatening the Norway spruce (Picea abies) dominated stands are caused by root rot due to Heterobasidion species, wind storms, and European spruce bark beetle (Ips typographus). In addition to growth losses and decrease in the timber quality, root rot decreases also tree stability against wind loading and thus increase the vulnerability of trees to uprooting and stem breakage. Bark beetles use the wind damaged trees as a breeding material and may emerge to outbreaks if large amounts of weakened trees are left in forest as unharvested. In our simulation framework WINDROT, a stand level decision support system MOTTI simulates the growth and dynamics of tree stands as affected by forest management, and provides inputs for mechanistic damage models simulating the dynamics and effects of disturbance agents. The simulation framework can be used to analyze the sensitivity of different forest management regimes to the risks posed by these damages alone and in interaction. The model performance analyses have showed that increasing root rot risk increases the risk for both wind damages and subsequent bark beetle outbreaks. In this sense, assessment of these risks to forests would be crucial for forest management under the changing climate.

root rot, bark beetle, wind, modeling, Picea abies

All Division 4 (Forest Assessment, Modelling and Management) Meeting

29 - Integrating climate change, disturbances and diversity effects into growth models: from understanding

K9 (Konzerthaus Freiburg)

IUFRO17-2995 **PINEA.pt - a tree growth and yield model for Pinus pinea L. in a multispecies and climate change paradigm**

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Abstract: Pinus pinea pine nut is the most important edible wild seed collected from Mediterranean forests. Retail prices for pine nut kernel exceeding 120 euros kg-1 for several years have been one of the causes for the increase of Pinus pinea area planted in Portugal (above 50% between 1995 and 2005 national forest inventories, representing the highest percent increase in Portuguese forest). The increase in stone pine area is mainly due to new plantations or to the interplanting of stone pine in the cork oak sparse stands. Most of Portuguese adult stone pine stands originated from natural regeneration and a large percentage is mixed with cork oak. Portugal has the largest stone pine area after Spain and Turkey , but, by far, the biggest cone production per unit area, with very sparse adult stands producing over six tonnes of cones per hectare.
In 2004 and 2005, 73 Pinus pinea permanent plots were established into the most productive region for cone production in Portugal, the V Provenance Region - "Charneca Miocénica e Pliocénica dos Vales do Tejo e do Sado" - in pure or mixed stone pine. The secondary species were cork oak, maritime pine or holm oak and the stands covered a large range of competition conditions and tree ages. Diameter at breast height, total height and height to the crown base and crown diameter have been measured in every tree in 2004/5, 2011 and 2015/6 in each plot. Cones have been harvested and weighted on a tree basis several years in each plot, in some plots for all 13 years since.
This data base was used to develop the PINEA.pt forest growth and yield model for the species, applicable to Portuguese conditions and taking into account the influence of other species and weather in all modules, allowing the simulation of tree growth and cone production considering multispecies stands and multipurpose scenarios in a changing climate perspective.

Pinus pinea; nuts; modelling; weather conditions

K9 (Konzerthaus Freiburg)

IUFRO17-1070 **Combining effects of mixing tree species and reducing stand density on radial growth during drought events**

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(1) Irstea, Nogent-sur-Vernisson, France

Abstract: Several forest management strategies can be used to cope with climatic changes. Reducing stand density and mixing tree species are two of them. Several studies investigated these strategies separately, but we do not know what the outcome would be if we used them conjointly.

The main objective of our study was to quantify tree species interactions effects on radial growth during a water stress period and to determine whether these effects changed with different levels of competition (different levels of stand density).
This study was based on a long term triplet experiment (OPTMix) made of pure and mixed stands of mature Quercus petraea and Pinus sylvestris in Orleans' forest (Central France). In this experiment, there are three repetitions of two densities (low and medium) in each composition (pure oak, mixed stands, pure pine). We followed radial growth of trees through 270 manual dendrometers spread over 21 plots. In each plot, the microclimate was monitored, and soil moisture sensors were set up at several soil depths in order to follow the drought.

We found that the mixture had no effect on oak growth, but a small negative effect on pines when there was a water stress during the summer. Investigations are still in progress to determine if this result depends on stand density.
Reducing stand density and the mixing of tree species are promising strategies, but understanding their combining effects still require further research.

seasonal growth, mixture, density

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4 - Open Session

K 1 (Konzerthaus Freiburg)

IUFRO17-517 **Developing Yield Model of Major Coniferous Species in South Korea**

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(1) Department of Forest Management, College of Forest and Environmental Sciences, Chuncheon, Korea, Republic of (South Korea); (2) Institute of Forest Science, College of Forest and Environmental Sciences, Chuncheon, Korea, Republic of (South Korea)

Abstract: This study was performed to develop yield model for major coniferous species in South Korea. For this study, Pinus densiflora, Pinus koraiensis, and Larix kaempferi were targeted and permanent plots were established in 38, 45, and 45 sites, respectively. Diameter at breast height (DBH) and height were measured in all the permanent plots. After the measurement, a standard tree was cut in each plot for stem analysis. Using the stem-analyzed data, stem taper equation and volume equation with two variables (DBH and height) were developed to calculate stand volume in each plot. In addition, site index for this study was developed following Schumacher and Chapman-Richards models. Relationships between stand volume and other variables, such as average DBH, dominant tree height, and number of trees per ha, stand age, basal area per ha, site index, etc., were compared through scatter plots and coefficient of correlation. Finally, stand age, basal area per ha, and site index were used as independent variables over stand volume for the yield model. Overall, scatter plots between stand volume and the independent variables showed linear relation and coefficient of correlation was high. The coefficient of determination for the final yield model was high in all the species. Therefore, this study is considered to provide the basic information on growth and yield for major coniferous species in South Korea.

conifer, permanent plot, site index, yield model

K 1 (Konzerthaus Freiburg)

IUFRO17-2360 **Determining nutrient sustainability of wood-biomass harvesting in German Forests based on monitoring data**

von Wilpert, K.* (1); Vonderach, C. (2); Ahrends, B. (3); Zirlewagen, D. (4); Weis, W. (5); Kändler, G. (2); Rumpf, S. (3); Sucker, C. (2); Puhlmann, H. (2)

(1) Forest Research Institute Freiburg, Kenzingen, Germany; (2) Forest Research Institute Freiburg, Freiburg, Germany; (3) NW-German Forest Research Institute Göttingen, Göttingen, Germany; (4) INTERRA, Bureau for Environmental Monitoring, Kenzingen, Germany; (5) Bayerische Landesanstalt für Wald und Forstwirtschaft, Freising, Germany

Abstract: Demand on biomass harvest continues to increase. Nutrient export is particularly high for fuel-wood harvest. However, nutrient export with harvest is not the only threat for the nutrient sustainability of forest soils, since soils in Central-Europe are widely affected by acid deposition. Thus, sustainability of nutrient cycles becomes a crucial question for silviculture.
We present results of a study in Germany with 11.4 Mio ha forests. Data on biomass and nutrient export were derived from the National Forest Inventory (NFI). Information on nutrient (Ca, Mg, K) input with deposition, weathering, and export with seepage was obtained from the Forest Environmental Monitoring and transferred to NFI sites by means of multiple regression modelling. The regression models explain approximately 70% of the parameter variance. The uncertainty in budget calculations was estimated by means of Monte-Carlo simulations.
The study revealed that under the present environmental conditions, about one third of the sites show negative soil nutrient budgets. That applies when the nutrient leakage with the soil seepage water exceeds the nutrient input by atmospheric deposition and rock weathering. Nutrient export by timber harvesting contributes to further deterioration of soil quality. However, for most sites, this nutrient export is much lower than the nutrient loss with seepage, with the exception of potassium. The results demonstrate the need to further decrease the input of acidifying compounds and to restore the forest soil quality by liming or wood ash application. This would require in the average a repetition of the measures roughly once per rotation period. Even if the harvest intensity including all assortments would be reduced - which would cause a harvest reduction of about 30-40% - the nutrient budgets would for some site and regions still be negative.

Sustainable harvest nutrientbalance decisionmaking

K 1 (Konzerthaus Freiburg)

IUFRO17-680 **Area-level analysis of forest inventory variables**

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Abstract: Small area estimation is a subject area of growing importance in forest inventories. Modelling the link between a study variable Y and auxiliary variables X - in pursuit of an improved accuracy in estimators - is typically done at the level of a sampling unit. However, for various reasons it may only be possible to formulate a linking model at the level of an area of interest (AOI). Area-level models and their potential have rarely been explored in forestry. This study demonstrates, with data (Y = stem volume per ha) from four actual inventories aided by aerial laser scanner data (3 cases) or photogrammetric point clouds (1 case), application of three relatively new area-level models. The studied AOIs varied in size from forest stands to forest districts, and municipalities. The variance explained by X declined sharply with the average size of an AOI. In comparison to a direct estimate mean of Y in an AOI, a model with a significant spatial location effect in a covariate achieved, in three cases a practically important reduction in the relative root mean squared error of an AOI mean. In one case two alternative non-spatial models achieved almost a halving of the relative root mean squared error in a direct estimate. Smoothing of estimated sampling variances had no practically relevant impact. In a forestry context, the pursuit of a spatial model component in area-level modelling appears promising.

EBLUP, nonstationary spatial effects

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4 - Open Session

K 1 (Konzerthaus Freiburg)

IUFRO17-2548 **Options for utilizing satellite LiDAR measurements in large-area forest monitoring**

Schnell, S.* (1); Saarela, S. (2); Holmgren, J. (2); Ståhl, G. (2); Olsson, H. (2)

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Abstract: In the near future new space-borne LiDAR systems for monitoring the Earth's surface will become available. Such systems can be considered as global sampling tools that have a great potential for facilitating the monitoring of forest resources in remote areas. To derive estimates of specific population parameters, field observations need typically be linked to the satellite measurements. Here, different approaches are possible: (1) field and satellite measurements are spatially aligned and can directly linked to each other or (2) the two sets do not cover each other and airborne laser scanning is used as an intermediate layer to link field observations to satellite data.

The different sampling strategies were evaluated using Monte-Carlo simulations of repeatedly drawing samples from a simulated population with known characteristics. For each population element, a full set of information from field, airborne laser scanning and satellite measurements was available. Model-based and design-based inferential frameworks were employed to estimate above-ground biomass for the entire population and within domains. A sensitivity analysis was conducted in terms of varying sample sizes.

The simulation study showed that for both approaches approximately unbiased estimators for population totals and variances are available and can readily be applied when data from space-borne LiDARs become available.

model-based, design-based, Monte-Carlo simulation

K 1 (Konzerthaus Freiburg)

IUFRO17-4094 **An Historically Consistent and Broadly Applicable Monitoring, Reporting, and Verification System Based on Landsat Time-series**

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Abstract: In the context of the United Nations REDD Programme, we tested and developed a biomass monitoring system based on a model using Landsat time series data that can be extended back in time annually to 1990. For the current period, the time series approach was compared with a design-based estimate using over 800 national forest inventory (NFI) plots and a model-assisted approach based on 50 field plots and lidar strip samples. At one site (one full Landsat scene) in Oregon, the three different approaches resulted in consistent estimates of total aboveground live biomass, with low uncertainties: 290 ±9 (10^6 Mg), 286±12 (10^6 Mg), and 280 ±5 (10^6 Mg) for the design-based, model-assisted, and model-based approaches, respectively. We then applied the model-based approach to every year from 1990 to 2016 to derive annual estimate of live biomass having an average uncertainty of 2.6% of the estimated live biomass. The annual biomass trajectory and Landsat 30-m maps derived from this approach revealed biomass patterns closely related to the site's disturbance history that was tied to forest management policy changes. We are further testing the model-based approach at five other sites distributed across different forest types in the US.

Landsat-time-series, biomass, REDD

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181 - Cross-boundary modelling in a changing world

Room "Colmar" (Novotel Freiburg)

IUFRO17-405 **Cross-Boundary Modelling - The Paradigm of our Time?**

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Abstract: Empirical modelling for projection has been a long-standing paradigm in forest science. This paradigm was also partly founded in the long tradition of an industry-driven science. Over the last 20-30 years this has changed fundamentally: Forest Science has gained more independence from industry requirements and has absorbed many staff and ideas from outside its own field. At the same time many new challenges had to be addressed and accommodated, e.g. the excellence trend in science and climate change. In some instances this trend has led to partial or full mergers with other fields of science and forest related research work has become more interdisciplinary. This has created a fruitful environment for many new unprecedented approaches in forest modelling and the purpose of this paper is to introduce the session of "Cross-boundary modelling in a changing world". Fields that have recently contributed a lot to forest modelling are plant physiology, physics, point process statistics and individual-based ecology. This introductory talk gives a systematic overview of the different types of cross-boundary models and their statistical and ecological motivation.

Trends, physiology, physics, spatial statistics

Room "Colmar" (Novotel Freiburg)

IUFRO17-107 **Modeling growth of trees by marked point processes evolving in time**

Särkkä, A.* (1)

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Abstract: We recall the so-called growth-interaction process, a time evolving marked point process, to model the growth of trees in a forest (Renshaw and Särkkä, 2001). According to the model, new immigrants (trees) arrive randomly in time according to a Poisson process, have uniformly distributed locations on the study region, and are assigned some initial sizes (diameters). In the successive small time intervals, each individual either dies according to a simple death process, or changes its size deterministically. The growth is determined by an individual growth function and an interaction function, which depends on the locations and sizes of the neighbouring trees. In addition to random death, a tree may die due to this interaction. We will give examples of the growth and interaction functions and discuss the estimation of the parameters of the model. Särkkä and Renshaw (2006) suggested a simple least squares method that compares the observed sizes of the trees with the model based sizes. The approach was improved first by Cronie and S ärkkä (2011), who added an edge correction to account for the trees that are not observed but affect the trees close to the boundary of the study region, and by Redenbach and S ärkkä (2013), who suggested to include the spatial structure of the tree pattern in the least squares comparison. The methods will be evaluated in simulation studies and applied to a Scots pine data in Sweden.

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Growth interaction; Least squares; Scots pine

Room "Colmar" (Novotel Freiburg)

IUFRO17-479 **Analysis and modeling spatial and spatial-ontogenetic structure of old-growth boreal forests by random point process models with hierarchical interactions**

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Abstract: Spatial relationships between trees play a fundamental role in forest ecosystems and their dynamics, governing together with other factors interaction, growth, mortality and regeneration processes in a plant community.
The study of spatial relationships is of great interest in plant ecology because it allows advancing our understanding of underlying ecological processes by testing hypotheses in a more refined way. However, the consideration of spatial dependencies is comparatively new and only recently advances in point process statistics and modelling of the last 3-4 decades allow us to explore this field of quantitative ecology in full details.
When studying a forest or plant community spatial and demographic aspects are tightly coupled: Spatial patterns are the result of past ecological processes and demographic changes of plant community. Both, temporal and spatial relations between trees can be captured under modelling by hierarchical interactions (Genet et al., 2014). We considered a hierarchical structure of interactions to account for the fact that competition between trees of different ontogenetic states is size-asymmetric. Unlike previous approaches, the new spatial model has the advantage of allowing a straightforward interpretation of its parameters in terms of inter-tree competition. According to the analysis, the random point process models with hierarchical interactions have the required flexibility to capture complex spatial tree patterns.

spatial patterns, inter-tree competition

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Room "Colmar" (Novotel Freiburg)

IUFRO17-2493 **Modelling canopy variables related to wildfire hazard with field data, LiDAR and other remote sensors**

Álvarez-González, J. G.* (1); Arellano, S. (1); González-Ferreiro, E. (1); López-Sánchez, C. A. (2); Ruiz-González, A. D. (1)

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Abstract: Accurate knowledge of fuel characteristics is critical in forest fire management, as fuel constitutes a primary component of fire risk. Wildfire planning is inherently spatial, requiring calculation, display and analysis of fire behaviour across large landscapes. Therefore, accurate fuel mapping is required for using fire simulation systems, which are essential for establishing fuel treatment priorities and evaluating the effectiveness of fuel management actions. One of the current main objectives of fuel management programs is the mitigation of crown fire hazard, because these fires are usually intense and spread quickly, which makes them difficult and dangerous to suppress.
Crown fire initiation and spread are widely recognized to be determined by canopy fuel complex variables such as canopy bulk density and canopy base height. Direct measurement of these variables is impractical at landscape level, and they are usually estimated indirectly by relating them to other traditional forest stand variables.
Remote sensing techniques (RS) have the capacity to obtain spatially explicit data over large areas in a timely and economic fashion. Specially, Airborne Laser Scanning (ALS) has proven to be a useful source of auxiliary data for describing the canopy fuel stratum, because it directly measures the three-dimensional structure of forest vegetation, while satellite imagery adds important quantitative information to predict forest variables at stand level.
Different approaches used to model the main canopy variables related to crown fire hazard from field data, ALS and satellite data are presented in this study. The main advantage of modelling using RS variables is that these variables and metrics are available for all population elements, and model-based inference could be used to predict the population value and its variance or to derive spatial-explicit maps of canopy variables distribution, thus enabling a more realistic and accurate prediction of crown fire potential.

canopy variables, pine stands, crown fires

Room "Colmar" (Novotel Freiburg)

IUFRO17-2936 **Mixed-effect models for nonlinear natural processes**

Mehtätalo, L.* (1); Peltola, H. (1); Laine, A. M. (2); Tuittila, E.-S. (1); Kilpeläinen, A. (1)

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Abstract: Linear models are suitable for such y-x relationships where g(y) can be expressed as a linear function of h(x); g and h are linear or nonlinear transformations. Nonlinear models allow also relationships that are nonlinear with respect to regression coefficients. The use of nonlinear transformations g(y) and h(x) in the linear model make it very flexible. Therefore, nonlinear models are not necessarily needed to model the nonlinearity of y-x relationship. However, they can be used to fit parsimonious models based on the theory of the underlying process. They allow model parameterization in terms of the parameters of interest and analyzing the effects of treatments and covariates on them. Random effects are often needed to take into account the grouped structure caused by the experimental setup and repeated measurements.

I will demonstrate the use of nonlinear mixed-effects models in two recent papers. The first paper models the effect of thinning on the annual tree growth using a sigmoidal logistic curve, which parameterizes the tree-level thinning effect using two parameters: (1) the reaction time needed to recover from the competition and (2) the full thinning effect in terms of annual growth after the recovery period. Model fitting in a Scots Pine thinning experiment showed that the reaction time is affected by the social position of the tree in the forest, whereas the full thinning effect is affected by the thinning intensity. The second paper models the response of Sphagnum moss on the available light using a hyperbolic light saturation curve, which is parameterized using three parameters: (1) respiration, (2) maximum photosynthesis, and (3) the linear response at low light level. The nonlinear mixed-effect model allowed us to analyze the effects of various factors such as water table, temperature, treatments and leaf area index simultaneously on all these parameters.

Nonlinear, mixed-effects, thinning, photosynthesis

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185 - Towards robust projections of forests under climate change

K 2-4 (Konzerthaus Freiburg)

IUFRO17-999 **Overview and results of the PROFOUND/ISIMIP multi-model comparison of climate change impacts on forests**

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Abstract: Changes in climate, environment and management are altering the world's ecosystems. Forests are of particular importance in this context due to the significant economic, ecological and cultural services they provide. Projecting changes of these services for the next decades is crucial for a concerted European response to environmental change. There are a number of challenges to meet. Mechanistic forest models that can be extrapolated to new environmental conditions are still associated with considerable predictive uncertainty. The reasons are the lack of harmonized datasets at larger scales and the difficulty to obtain robust methods for parameterisation, evaluation and model comparison that make optimal use of the range of available data types and sources. This presentations gives an overview of the main achievements of the "COST Action FP 1304 Towards robust projections of European forests under climate change" (PROFOUND) with a particular focus on its harmonized, multi-model projections of climate change impacts on European forests. The database, model protocol and key results are being presented and discussed within the framework of the wider, cross-sectoral Inter-sectoral Impact Model Intercomparison Project (ISIMIP).

COST Action, Forest models, Uncertainty

K 2-4 (Konzerthaus Freiburg)

IUFRO17-545 **Models and data available for projecting future forest functioning**

Ruiz-Benito, P.* (1); Hartig, F. (2); Lines, E. (3); Morin, X. (4); Reyer, C. (5); Mäkelä, A. (6); Palacios, A. (7); Yousefpour, R. (8); Vacchiano, G. (9); Lehtonen, A. (10); Ibrom, A. (11); Zavala, M. A. (1)

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Abstract: It is critical to increase our current understanding of how to best use models and data to generate knowledge and evaluate climate change impacts, risks and its uncertainty in European forests. There is a wide variety of models to inform about climate change impacts and risks on ecosystem services, including provisioning, regulating, supporting and biodiversity. Models range from e.g. empirical models to process-based species distribution models, forest stand and gap models or DGVM. Generally, certain ecosystem services in forests are well described at different spatial and temporal resolutions and extents, as e.g. growth/productivity, biomass or species presence/absence. There is, however, other functions/characteristics poorly described as e.g. intra-specific and genetic variability, regulating services and responses to extreme climatic and interactive events. We identified databases available of forest responses and drivers across Europe and match these data with the data needs of different models. The main constraint is data available at high spatial resolution and large spatial extents about certain ecosystem services (and mainly those related with regulation) and drivers (e.g. climate, disturbances, management). Overall, we suggest future generations of process-based models with combined data from different sources (e.g. remote sensing, observational data) will pose a major advance on knowledge about of climate change impacts and future risks.

climatic extremes, data, ecosystem services

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3214 **Bayesian inference for linking process-based forest models to data - state-of-the-art and challenges**

Hartig, F.* (1); Cameron, D. (2); Dietze, M. (3); Minunno, F. (4); Reineking, B. (5)

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Abstract: Process-based forest models offer significant advantages over more empirical modeling approaches, particularly for predicting transient dynamics and forests responses to novel climatic conditions. A persistent problem, however, is their parameterization. Traditionally, model processes and parameters are determined by independent measurements and expert knowledge, and model outputs are compared to empirical data for validation and informal model comparison only. However, this approach has a number of limitations. Firstly, many model parameters are difficult to measure, or not measurable at all. Secondly, constraining parameters by direct measurements only disregards a large range of forest data on model outputs, such as data from inventories, distributions, remote sensing, eddy covariance or palaeorecords. And thirdly, uncertainty is difficult to assess and integrate in the traditional parameterization paradigm. This talk will focus on Bayesian solutions to integrating a wide range of forest data into process-based forest models. We will discuss the state-of-the-art of this approach and present software solutions, protocols and case studies developed by the COST Action PROFOUND. Despite some open challenges, the experience of PROFOUND highlights the potential of Bayesian inference as a consistent framework for model-data integration, with an unrivaled possibility to integrate and project uncertainties, the latter being highly relevant for practical policy advice.

Bayesian, calibration, uncertainty

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K 2-4 (Konzerthaus Freiburg)

IUFRO17-1157 **Modeling changing forest disturbance regimes**

Seidl, R.* (1); Thom, D. (1); Kautz, M. (2); Martin-Benito, D. (3); Peltoniemi, M. (4); Vacchiano, G. (5); Wild, J. (6); Ascoli, D. (7); Petr, M. (8); Honkaniemi, J. (4); Lexer, M. J. (1); Trotsiuk, V. (9); Mairota, P. (10); Svoboda, M. (9); Fabrika, M. (11); Nagel, T. A. (12); Reyer, C. P. . O. (13)

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Abstract: Around the globe natural disturbances are responding to ongoing changes in climate, increasingly challenging ecosystem management. Yet, our understanding of disturbance change remains fragmented, limiting our ability to include disturbance impacts in simulations of future forest trajectories. In order to advance forest disturbance modeling in a changing world our objectives were (i) to synthesize general pathways of climate impact on forest disturbance regimes from the literature, and (ii) to highlight implications for simulation modeling and suggest ways forward for increasing the robustness of future disturbance projections. We base our analyses on a comprehensive global synthesis of climate effects on disturbances from fire, drought, wind, snow & ice, insects, and pathogens. We demonstrate that climate change will have substantial direct effects on disturbances, but also alters disturbance regimes via indirect (i.e., vegetation-mediated) impacts as well as changes in disturbance interactions. We subsequently contrast these profound impacts of climate change with the state of the art in disturbance modeling, which is still widely dominated by empirical approaches and largely focuses on simulating disturbance agents individually. Here we argue that in order to capture the effects of changing disturbance regimes in future projections it is important (1) to apply process-based models that are robustly able to parse no-analog future conditions, (2) to jointly consider effects of climate change on disturbances and vegetation, and the dynamic feedback between them, and (3) to explicitly consider the interactions between different disturbance agents in simulations.

natural disturbances; simulation modeling

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3518 **Different formulations of tree mortality lead to vastly different forest dynamics: an assessment across 15 models from the stand to the global scale**

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Abstract: Dynamic Vegetation Models (DVMs) are pivotal for assessing future forest dynamics. They include formulations of tree growth, mortality, and regeneration, but quantitative knowledge for developing robust models of tree mortality is scarce. We evaluated 15 DVMs in terms of their sensitivity to different formulations of tree mortality. While some mortality models are based on long-term monitoring data, others rely on experiments, and some employ theoretical reasoning alone.
Each DVM was run with at least two alternative mortality algorithms. First, model behavior was evaluated against past time series data. Second, the models were subjected to various scenarios of climate change for the 21st century.
Most DVMs matched empirical data well, irrespective of the mortality formulation . It turned out to be generally difficult to assess the suitability of a mortality formulation based on past model behavior only. However, mortality algorithms that performed in a very similar manner when evaluated against past data were often found to lead to sharply different trajectories of future forest dynamics. Model sensitivity to the mortality formulation was about 2-3 times larger than model sensitivity to the climate change signal. Thus, it is indispensable to employ several alternative mortality formulations in DVMs when assessing future forest dynamics.

Tree mortality; Global Change; Dynamic Model

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1688 **Modelling carbon allocation in forest ecosystems**

Merganicova, K.* (1); Merganic, J. (2); Jonard, M. (3); Lehtonen, A. (4); Ostrogovic Sever, M. Z. (5); Mäkelä, A. (6); Reyer, C. (7); Fabrika, M. (2); Grote, R. (8); Vacchiano, G. (9); Collalti, A. (10)

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Abstract: Allocation of carbon to plant organs is considered as one of the most important plant adaptation mechanisms to environmental changes. Several empirical studies presented that carbon partitioning between individual plant organs depends on environmental conditions and stand structure. From the modelling perspective, carbon allocation is one of the crucial modules that affect the final outcome of forest simulators. A variety of different modelling approaches of carbon allocation from simple methods based on fixed ratios up to highly sophisticated thermodynamic approaches have been developed. They differ in the complexity and sensitivity to changes in site and stand conditions. In the presented study we examine which modelling approaches of carbon allocation are most frequently used in forest simulators and analyse how environmental factors affect the modelled partitioning of carbon. The study is based on the information gathered with a questionnaire distributed to forest model developers worldwide. The results identify the possibilities to improve carbon allocation modelling in forest simulators to enable them to appropriately reflect the ongoing changes in forest ecosystems in their output.

carbon partitioning, environment, model, pool

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Room "Colmar" (Novotel Freiburg)

IUFRO17-463 **Natural data assimilation with a view to forestry**

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Abstract: We introduce natural data assimilation which is a particle filter applied to a dynamical system for which the state model is replaced by a catalogue of measurements of historical state transitions and where á priori estimation of the state is done by finding successors of nearest neighbours in the catalogue. When applied to an Ornstein-Uhlenbeck process, simulations indicate natural data assimilation to be comparable to the optimal Kálmán filter. We also describe a possible application of natural data assimilation to forestry, where the technique might be used to deliver timely estimates of important forest characteristics based on remote sensing measurements.

Bayesian filter; Forest inventory; Remote sensing

Room "Colmar" (Novotel Freiburg)

IUFRO17-4070 **Balancing bioenergy production and ecosystem services in the Alps**

Leduc, S.* (1); Mesfun, S. (1); Patrizio, P. (1); Serrano Leon, H. (1); Kindermann, G. (1); Fuss, S. (2); Kraxner, F. (1)

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Abstract: The role of renewable energy (RE) is considerably increasing due to the goal sets by the European Union by the year 2020 as well as the withdrawal from the nuclear power production from Germany, Switzerland and partially Italy. In that respect, the Alps may be called the tank of Europe, but this encounters that its resources are properly managed and used in a sustainable way. At the same time The Alps have a fragile ecosystem threatened by the raise of global temperature. The economic and environmental potential will be address in order to identify the balance between the production of bioenergy and the protection of ecosystems services.
The model applied is a techno-economic model, geographically explicit, BeWhere, that optimizes the location, capacity and technology of future production plants, based on the minimization of the cost and emissions of the whole supply chain. Woody based biomass is the selected feedstock that can be managed in a business as usual, production intensification or carbon sequestration maximization scenario. Different bioenergy technology ranging from small medium and large scale are studied. All definitions of the protected areas in the Alps are harmonized together with their geographic location to assess the level of human activities in each of them. Energy scenarios specific for each country that belongs to the Alpine region will be run, in order to identify the bioenergy potentials from the woody based biomass and as well as the best management practice.
The preliminary results show that a full protected scenario increases the cost of bioenergy production by at least 25% compared to a business as usual scenario for a production of 15PJ. At the same time this will leave room for half of the Alps to be managed following a carbon sequestration practices which will capture twice the amount of carbon compared to intensive biomass management practices.

The Alps, bioenergy, BeWhere, ecosystems services

Room "Colmar" (Novotel Freiburg)

IUFRO17-1393 **Genetic variation may buffer effects of climate change on distribution of forests: a trans continent application of species distribution model**

Chakraborty, D.* (1); Schueler, S. (1); Lexer, M. J. (2); Wang, T. (3)

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Abstract: Species distribution models (SDMs) are one of the most widely used tools to assess the impact of climate change on forest trees and ecosystems. However, lack of mechanistic basis and explicit consideration of genetic variation are two important limitations for their application to novel climate regimes expected in the future. With data from 50 provenance trials of Douglas-fir (Pseudotsuga menziesii [Mirbel] Franco) in Austria and Germany we developed Universal Response Functions (URFs) that predicts growth performance of populations (dominant height and basal area) as function of both climate of planting locations (environmental effects) and climate of seed origin (genetic effects). The URFs were applied as SDMs (URF-SDMs) by converting growth performance to species occurrence by truncating the lower end of the response curve. As a retrospective model validation the URF-SDMs were applied to predict observed presence and absence of Douglas-fir at 70000 locations in North America. The URF-SDMs were also applied to predict suitability of Douglas-fir in Europe and North America for different seed origin and climate change scenarios. Even though developed from data in Central Europe the accuracy of the URF-SDMs were surprisingly high and comparable to contemporary SDMs developed in North America based on presence/absence data or process-based models. The URF-SDMs predict contrastingly different suitability of Douglas-fir under climate change depending on the seed origin. The flexibility of the URFs as a decision making tool is remarkable. The URFs can be applied to identify the best-performing planting stock for any location under current and future climate and to map the most appropriate future habitat for a given planting material. Our results suggest that integrating genetic variation of functional traits into SDMs will considerably broaden SDM applications from climate change impact studies to decision-making in forest and conservation management.

climate change,species distribution model

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K 2-4 (Konzerthaus Freiburg)

IUFRO17-1452 **Climate drivers of regional forest dynamics**

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Abstract: Forest simulation models have proved extremely useful in understanding forest dynamics by scaling from tree-level processes to landscape scales. However, typically their demographic sub-processes contain no climate dependencies, limiting their usefulness for understanding the role of climate in shaping forest structure and for predicting the impact of climate change. National forest inventory databases may be exploited to investigate the role of climate on tree-level processes, and the climate drivers of geographical ranges of different species, by making a space-for-time substitution. We demonstrate the value of inventory data for determining the climate drivers of forest processes. By scaling up from individual demographic rates using a forest simulation model, parameterised for mainland Spain, we determine the key climate dependencies driving emergent forest properties, allowing defensible predictions of the impacts of climate change.

Forest modelling; climate change; demography

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3460 **Modeling forest dynamics across Europe: What can we learn from global sensitivity analysis?**

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Abstract: Dynamic vegetation models, particularly forest gap models (FGMs), have been suggested as suitable tools for predicting species ranges and range shifts because they explicitly represent population and community processes and allow us to understand non-equilibrium situations. However, few FGMs have been applied across large spatial scales so far, e.g. across Europe. This may be due to parameterization problems and insufficient or biome/site-specific representations of mechanisms.
We assess the behavior of a state-of-the art FGM (ForClim) across Europe by evaluating its sensitivity to parameters and underlying ecological processes along a broad environmental gradient. We conduct a global sensitivity analysis of the model at 30 sites covering the main environmental conditions of Europe.
The most influential parameters are related to tree establishment, the water and light regimes, growth and temperature, whereby the importance of the latter strongly varies in space. Further, parameter importance differs strongly between monospecific and mixed stands as well as between early and late succession. We identify key parameters for Bayesian model calibration and structural model deficiencies that need to be addressed by improving process representations (e.g., of drought impacts) so as to improve the robustness of model projections under changing climatic conditions at the European scale.

forest gap model,sensitivity analysis, mixtures

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2217 **Identifying the knowledge gap between climate change forest-impact modelers and stakeholders**

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Abstract: Decisions on climate change adaptation critically depend on the information on which they are based. This paper reports the first results of a study aiming to identify the knowledge gap between climate change forest-impact modelers and stakeholders. The study is being conducted in the COST action PROFOUND and the results reported are based on 748 responses to an online survey to which all PROFOUND scientists and stakeholders from 10 European countries had been invited in a systematic way. The survey includes questions relating to the perceptions of climate change and its impacts on forests, options for adaptation as well as the tools developed to research these issues. Based on the results presented, the paper discusses strategies for the adequacy of communications with respect to climate change impacts on forests and options for adaptation.

communication; climate change; adaptation

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62 - Forest models developed from census data containing errors

K 5-7 (Konzerthaus Freiburg)

IUFRO17-682 **Integrating silviculture and operational plans using real time decisions**

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Abstract: Thinning is focused on providing intermediate goods and service while redistributing growth to remaining trees. In practice, the goal of thinning is to determine which trees are to be removed that yield the best combination of immediate goods and services plus their removal effect on the adjacent trees. Instructions or criteria are developed for the implementation crew as which trees are to be removed. We propose a new thinning method that improve overall stand value, which combines remote sensing technologies with growth and yield models at the operational level. First, above canopy point cloud data are used to identify tree locations, and execute a value analysis on the target trees and adjacent trees. Second, below canopy camera images will supply the spatial information for cutting criteria in real time considering the target tree and adjacent tree effects. Finally, tree identification using above canopy data includes omission and commission errors. To ensure complete representation of all trees within stand, results with commission errors are used. Processing time for wall to wall representation of stand to which erroneous trees are added are not significantly larger than non-erroneous data, as simulations suggest less than 2 min /location.

tree value; computer vision; segmentation

K 5-7 (Konzerthaus Freiburg)

IUFRO17-686 **Establishing Confidence Envelopes for Trends and Their Derivatives in Phenological Time Series**

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Abstract: An important quest in ecology over the past two decades is to estimate the effects of warming on ecosystems based on long-term observations, which should be trends over the time span considered. To understand the characteristics of the trends, it is imperative to estimate their 1st- and 2nd-derivatives and to establish confidence envelopes (CEs), which are challenging tasks because of the nonlinear and nonstationary nature of most of the ecological time series.
The present study combined ensemble empirical mode decomposition to extract trends and estimate their derivatives, and maximum entropy bootstrap to establish CEs. Both methods do not require a structural, distributional, linear, or stationary assumption, and can be executed in parallel because of their single instruction multiple data nature, which will efficiently provide realistic CEs based on large sample sizes. A case study was presented by extending a previous work, which extracted the trends of a blackthorn (Prunus spinosa L.) first flowering date (FFD) anomaly series and its corresponding temperature anomaly series. Bootstrap samples was decomposed individually to extract trend, and its 1st- and 2nd-derivatives were estimated by 1st- and 2nd-order differencing, respectively. CEs for the trends and their derivatives of the observed series were then established.
Although the extracted trends and their derivatives of the observed series corresponded well, the established CEs indicated that there were time lags between the two trends and between the corresponding derivatives with FFD leading. More importantly, the established CEs indicated that the acceleration would begin to decelerate quickly soon after a significant increase in temperature or advancement of FFD could be declared. Thus, further investigations of the relationship between the two series and the nature of recent warming are warranted.

EEMD, Maximum entropy bootstrap

K 5-7 (Konzerthaus Freiburg)

IUFRO17-719 **Forest structure assessment based on terrestrial laser scanning**

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Abstract: Currently, objective and quantitative indices to describe forest structure typically rely on easy to measure tree characteristics, typically height and/or diameter. They do not account for variation in tree allometry or represent the stand structure holistically. Therefore, conventional tree-based indices of forest structure as described above may not be a suitable tool to address ecosystem functions and services related to forest structure, such as biodiversity, productivity, or resilience.
Terrestrial laser scanning (TLS) allows for a direct measurement of the three-dimensional stand structure. We present a new complexity measure that is based on TLS taken in various stand types in the USA and Germany. We took almost 1500 single scan measurements and used these data to calculate the mean fractal dimension (FD) of 1280 polygons per scan, with each polygon being a cross-section through the laser-based point cloud of the stand. The effective number of layers (ENL), a laser-based measure of vertical heterogeneity, was then used to scale the mean FD according to the vertical heterogeneity of the stand, i.e., each dimensionless FD-values was related to the spatial frame (stand dimensions) it was measured in. The resulting index of stand structural complexity (SSC) proofed to be a meaningful measure of structural complexity that was able to objectively distinguish the different stand types. In addition, it was also related to measures of tree species diversity ($r^2 = 0.14$; $p<0.001$), as well as microclimatic measures such as the variation in the mean daily temperature ($r^2 = 0.39$; $p<0.001$) or vapor pressure deficit ($r^2=0.19$; $p<0.001$); suggesting that SSC is not simply a measures of stand structure, but also contains information about important ecosystem processes.

Fractal dimension, holistic, complexity

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62 - Forest models developed from census data containing errors

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3653 **Forest tree species mapping with use of Sentinel 2 imagery and forest inventory data: the case study in the Polish Carpathians**

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Abstract: The Polish National Forest Inventory (WISL) is a primary source of data on forests and their changes in Poland. It is a relatively accurate, complete and timely database updated in every 5-years cycles since 2005. Observations and measurements are performed on fixed sample plots. Each L-shaped group of sample plots consists of 5 plots spaced 200m and groups are spread over a network of 4x4 km.
In this study we processed the described above WISL data and assessed their advantage of use in forest tree species classification based on satellite images. We used here Sentinel 2 data. The study area was located in the Polish Carpathians, where forests are characterized by significant heterogeneity, both in terms of species composition and other forest characteristics (e.g. forest stand age, property). We focused on assessment, if the WISL data (cycle II, 2010-2014), taking into account the spatial distribution of sample plots and their sizes, can be used as a reliable reference data for classification in both regional (the entire Polish Carpathians) and local (particular a forest district) scale.

We gratefully acknowledge support by the National Science Centre, project RS4FOR [project no. 2015/19/B/ST10/02127].

forest species classification, remote sensing

K 5-7 (Konzerthaus Freiburg)

IUFRO17-4092 **A meta-analysis of loblolly pine growth and yield studies in the southern U.S.**

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Abstract: Loblolly pine (Pinus taeda L.) is the most commercially important forest species in the southern U.S. The performance of the species has been methodically studied for almost a century; therefore, there is abundant information on loblolly pine growth. However, few studies have been aimed at compiling this information. The aim of this research is to use meta-regression to statistically synthetize suitable loblolly pine growth and yield studies in the southern U.S. As a theoretical framework, the growth and yield models were split into a few core factors: age, site quality, genetics, density, and management. There were 18 studies selected out of over 500 papers evaluated. Growth factors were included in the Schumacher model to estimate yield for four dependent stand level variables: diameter at breast height, total height, basal area, and volume. All growth and yield factors were statistically significant in the diameter and height models, but genetic background was not statistically significant in the basal area and volume models. Meta-analysis and meta-regression are very promising techniques in forestry to strengthen conclusions about the effect of factors related to growth and yield of important forest species. Consolidated the information about loblolly pine growth and yield using statistical procedures should lead to more reliable estimations to implement in forest planning and operations, reduce the uncertainties associated with yield estimates, and to enhance the analyses of timberland investment. However, more steps are required to improve estimated models in this research: increasing the number of selected studies, trying different factors/variables arrangements, and including interactions.

Pinus taeda L., genetically improved trees

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4 - Open Session

K 1 (Konzerthaus Freiburg)

IUFRO17-3225 **Price Impact Analysis of Increased Biofuel Production on Forest Feedstock Markets: A Spatial Explicit Approach for Sweden**

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Abstract: This paper introduces a model of price determination to analyze the impacts of increased biofuel production on forest feedstocks markets in Sweden. The model is based on a spatially-explicit, demand-supply framework. Data on forest biomass supply and harvest cost at the gridcell level is available for Sweden for 334 0.5x0.5 degree gridcells. We use the data to construct supply curves, both at the national level and sub-national level. The supply and harvest cost data is available for four forest commodities: branch & tops, pulpwood, sawlogs and stumps. The latter are further distinguished depending on the type of harvest operation: thinning or final felling. On the demand side, the model is calibrated using data on current demand for each feedstock at gridcell level. Demand scenarios for different biofuel targets are generated from the BeWhere-Sweden model at the gridcell level, which allow us to investigate the potential impacts on market price as approximated by the harvest cost data. We run simulation scenarios for increased biofuel production from forest biomass for Sweden: a 10 and 20 terawatt hour (TWh) of biofuel by 2030. As expected, the results show that increased demand pressure on the forest biomass will tend to push prices up. The magnitudes of change are highest for pulpwood and branches & tops from final felling, where they reach 0.004% to 18.95% and 0.001% to 7.2% respectively. With respect to the spatial distribution of price change, we notice that it matches expectations as they map out with the spatial distribution of supply and demand.

Biomass, Forestry, Sweden

K 1 (Konzerthaus Freiburg)

IUFRO17-1081 **A Monte Carlo appraisal of the estimation of forest tree abundance and basal area by terrestrial laser scanning**

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Abstract: Terrestrial laser scanning (TLS) provides a measurement technique that can acquire accurate level of detail from the surrounding area, which allows rapid and automatic recording of several forest attributes. However, non-detection of trees is a serious problem for the use of TLS in forest surveys because there is no way to achieve the actual inclusion probabilities of detected trees until some assumption on the detection process are introduced. We assume a detection function giving the probability of detecting a tree at a given distance from the point at which TLS is located. We use the conventional distance sampling to determine the inclusion probabilities of detected trees and subsequently develop adjusted estimates of forest tree abundance and basal area in a hybrid inferential approach. A simulation study is performed to compare the distance sampling estimator based on a beta detection function with the Horvitz-Thompson estimator based on conventional plot sampling. We have stipulated several values for the maximum distance. Regarding the sampling design, TLS measurement points and the corresponding plots used for the comparison are assumed to be located in accordance with uniform random sampling and tessellation stratified sampling.

distance sampling, plot sampling

K 1 (Konzerthaus Freiburg)

IUFRO17-349 **Geostatistical model-based estimation of forest biomass in interior Alaska combining landsat derived tree cover, sampled airborne lidar and field observations**

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Abstract: Lidar data provide critical information on the three-dimensional structure of forests. However, collecting wall-to-wall laser altimetry data at regional and global scales is cost prohibitive. As a result, studies employing lidar data for large area estimation typically collect data via strip sampling; leaving large swaths of the forest domain unmeasured by the instrument. The goal of this research was to develop and examine the performance of a geostatistical coregionalization modeling approach for combining field inventory measurements, sampled airborne lidar, and landsat-based data products to predict aboveground biomass (AGB) in interior Alaska's Tanana Valley. The proposed spatial modeling strategy facilitates point-level mapping of AGB density and provides a statistically sound approach for estimating total AGB for areal units. This research is keenly focused on the appropriate characterization of prediction uncertainty in the form of predictive coverage intervals and standard errors. Using the framework detailed here, it is possible to quantify estimation uncertainty for any spatial extent desired, ranging from pixel-level predictions of AGB density to estimates of AGB stocks for the full domain. The lidar informed coregionalization models consistently outperformed their counterpart lidar-free models in terms of point-level predictive performance and total AGB precision. Additionally, the inclusion of landsat-derived forest cover further improved estimation precision in regions with lower lidar sampling intensity. Our findings also demonstrate that model-based approaches that do not explicitly account for residual spatial dependence can grossly underestimate uncertainty, resulting in falsely precise estimates of AGB. On the other hand, in a geostatistical setting, residual spatial structure can be appropriately modeled within a Bayesian hierarchical framework to obtain statistically defensible measurements of uncertainty for AGB estimates.

Bayesian hierarchical model; small area estimation

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103 - Operationalising forest degradation assessment for REDD+

K 1 (Konzerthaus Freiburg)

IUFRO17-2420 **Identification of forest carbon stock change using Landsat data and field data for REDD+ reference setting**

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Abstract: This study aims to identify forest carbon stock change using Landsat data and field data for REDD+ reference setting. We acquired time-series Landsat images of Cambodia, and field survey was carried out to estimate forest carbon stock at the grids with 3-km interval where interpretation of land cover type was conducted on the Google Earth to obtain ground truth data and verification data of the classification. After atmospheric correction of Landsat data, we performed object-based classification using them. Statistics on reflectance in each band of Landast data were also calculated for those objects. We made an object-based model to estimate forest carbon stock from the satellite data by multiple regression analysis using the field-based carbon stock estimate as the object variables and statistics of satellite data as explanatory variables. Forest carbon in each object was divided into three class for evergreen forest and two classes for other forest types, and classes of forest carbon stock were mapped. We identified and mapped changes to a small forest stock class using carbon stock class maps of two different dates to identify forest degradation. This approach makes it possible to introduce evaluation of loss by forest degradation in REDD+ reference setting.

REDD+, reference, object-based classification

K 1 (Konzerthaus Freiburg)

IUFRO17-1368 **New sustainable business models in forest bio-economy to gain added value for rural areas**

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Abstract: Being competitive in processing and refining forest raw-material induces economic value (EV). Although the two value chains of wood chips and non-wood forest products (NWFPs), presented in this paper, operate under different conditions and business-strategies, it is equal to both that the added value they gain depends economically on the refinement strategy and socially on sustaining jobs and rural vitality. Thereby, technical and digital progress and the mutual dynamics of rural urban relationships are decisive to professionalize marketing and logistics for extending the demand of domestic forest products. The paper analyses key factors enabling sustainable bio-economic business-models, how they impact rural economy and if that is an appropriate recipe to diminish the rural urban divide. Case studies are taken as references to identify best ways to use funds and for defending exigency to introduce new forest and NWFPs products according the purpose assessment of resources and probable market opportunities. Thereby, light is shed on the horizontal and vertical contributions of actors and intermediate suppliers along the value added chain. By means of the Boston Consulting Group (BCG) matrix, the growth rates of purchase, sales, domestic and export markets are evaluated. Additionally, the conflicts between micro-economic interests and macro-economic benefits are stated. Thereby, cascade timber-processing according to the materialistic or energetic timber-usage or interdependencies between silvicultural management and required site-conditions for NWFPs are also discussed.

bio-economy, value added chain, interest-conflict

K 1 (Konzerthaus Freiburg)

IUFRO17-842 **Analyses of value added chains and changes in value added in the wood-processing industries in Germany**

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Abstract: In the past years, the demand, and therefore the competition, for wood and timber use in Germany has increased strongly. Especially the increasing nature protection requirements for German forests result in a reduction of the domestic wood-supply available for the German timber industry.

Against this background, we developed and applied methods for the assessment of the economic impacts of changes in wood-supply for the German wood-processing industries.

We developed a method for determining average figures of value added and employment of wood-based value added chains, using official statistics. Based on these figures, the average value added and employment through use of an average unit of wood or wood-based intermediate input and, subsequently, the effect of changes in wood-supply can be estimated in wood-based value added chains.

By means of a decomposition analysis, we evaluated the effects of value added and the role of wood as intermediate input in the sawmilling and wood processing industries. Based on statistical data, we developed a decomposition method that can be used to determine changes in product and intermediate input prices as well as in growth and structural effects. A special focus was set on the impacts of price and quantity changes based on the input of wood-based products. For the sawmilling industry a connection between wood input and economic growth could be detected. Furthermore, the high importance of wood and wood-based inputs for the sawmilling industry could be shown.

value added chains, timber industry, decomposition

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4 - Open Session

K 1 (Konzerthaus Freiburg)

IUFRO17-1351 **The last primary forest remnants in Europe: their spatial distribution and determinants**

Sabatini, F. M.* (1); Burrascano, S. (2); Keeton, W. S. (3); Levers, C. (1); Lindner, M. (4); Pötzschner, F. (1); Verkerk, H. (4); Kuemmerle, T. (1)

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Abstract: The widespread historical deforestation and exploitation of forests for wood products have led to the almost complete disappearance of virgin forests from Europe. When not intensively influenced by humans, forests recover through secondary development and accumulate structural features (e.g. deadwood, large trees, species composition) typically associated with late-successional dynamics. For several reasons, including some de-intensification of forest management, the proportion of structurally complex forests has increased in many European countries in the last decades, with benefits for ecosystem services and biodiversity.
Identifying both virgin and late-successional forests, here jointly indicated as 'primary' (i.e. relatively intact forest areas that have always or at least for the past eighty years been essentially unmodified by humans), is crucial for addressing key forest ecosystem sustainability issues. These include developing a better understanding of forest natural dynamics, assessing biodiversity baselines, and exploring synergies and trade-offs among ecosystem services and biodiversity.
Yet, many primary forests remain undiscovered and unprotected, especially in Eastern Europe. We produced the first map of known European primary forests aggregating information via: 1. a thorough interdisciplinary literature review (>600 papers checked), 2. an online questionnaire (sent to ~130 experts), and 3. the creation of a network of 31 forest experts from 23 countries. Using this data and a comprehensive set of biophysical and socio-economic variables, we developed a spatially-explicit model to understand the spatial determinants of primary forest persistence and re-development. We show that historical land-use patterns were constrained by specific environmental and socio-economic conditions in the European context, and predict the possible occurrence of other, but overlooked, stands in areas with similar characteristics compared to existing primary forest remnants.

old-growth, virgin forest, spatial determinants

K 1 (Konzerthaus Freiburg)

IUFRO17-1628 **Convergence and diversity: international comparability of forest accountancy data networks and approaches for assessing the economics of small-scale farm forestry in the DACH-region**

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Abstract: The countries of the DACH-region [Germany (D), Austria (A) and Switzerland (CH)] share a long tradition in monitoring the economic situation of bigger forest enterprises by means of forest accountancy data networks (FANs). In spite of general similarities, international comparisons and benchmarking exercises are hampered by the diversity of definitions as well as sampling and accounting concepts. The paper reflects potential misinterpretations of differing results from national FANs and highlights the hitherto achieved advances of the so-called "DACH-Initiative". By designing adapted reports, introducing additional items and agreeing on common definitions, the compatibility of the data could be improved substantially. Nevertheless, some fundamental differences remain so that sound comparisons still require experts' knowledge.
Due to the different patterns of forest ownership, the economics of small-scale farm forestry (SSFF) is more or less significant for sector statistics in the three countries. Hence, the DACH-region provides references for assessing SSFF at quite different levels of sophistication and thus also up-to-date evidence for the range of approaches identified by the EU project on Monitoring the Socio-Economic Situation of European Farm Forestry (MOSEFA). National farm accountancy data networks focussing on agriculture prove to be more or less suitable for this purpose. Economic modelling may even allow for representative results as demonstrated in the case of Austria.

ratio analysis, small-scale forestry, MOSEFA

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99 - Adaptive spaces: can forest planning support innovative forest practice and knowledge co-creation

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2605 **Forest planning, innovative practice and knowledge co-creation: an overview**

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Abstract: Forestry is characterised by hierarchical and planning processes, but these traditions have been challenged for more than a decade as forest management priorities and practice evolve away from a single focus on sustainable timber yields and towards a diversity of management objectives. In recent years these challenges have increased as researchers and practitioners highlight uncertainties related to climate change and other aspects of 'global' change including economic and political, and call for resilience. New paradigms for natural resource planning have been recommended by many academics, planning theorists, and practitioners.

This paper is an overview paper which sets out the issues and a framework for the papers in this session. It reviews forest planning; knowledge transfer and knowledge exchange processes within that framework (command-and-control vs. alternatives); uncertainty, innovation, learning and knowledge generation processes; and the relationship with resilience. It organizes contributions around two questions: how do forest practitioners cope with uncertainty, particularly in relation to knowledge and innovation; and how can forestry planning structures support practitioner innovation, knowledge co-production and integration of experiential learning with more conventional scientific knowledge. We set out an agenda for researching options for knowledge exchange, enabling environments and institutional reforms to complement efforts to improve knowledge exchange, and the implications for forest planning.

knowledge exchange, adaptive management

K 5-7 (Konzerthaus Freiburg)

IUFRO17-855 **Coping with uncertainty - exploring the adaptive capacity of Dutch forest managers**

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Abstract: The rapid and turbulent changes in our world create large uncertainties for forest managers on a myriad of factors, such as the climate, market conditions, legal frameworks, and their impacts. Over the last decade, incorporating resilience in forest management as a way to acknowledge and operate under these large and uncertain changes, has become more and more prominent. Rist and Moen (2013) even talk about resilience-based approaches as a new management paradigm. Planning for resilience in forest management, however, requires an understanding of forest managers' ability to adapt to changes. Therefore, in this research, we examine the adaptive capacity of Dutch forest managers. Using Protection Motivation Theory as a framework, two cognitive factors, i.e. perceived risk perception and perceived adaptive capacity, are determined. Both factors combined have been shown to play a strong role in whether an individual adapts to change or not. Data are collected using an online survey directed to both public and private forest managers, responsible for the day-to-day management of areas varying in size between very small (< 5 ha) to very large (> 1000 ha). The results of the survey form, in combination with data from the 6th National Forest Inventory, an indication of the Dutch forest area where managers feel able to cope with changes, as an indicator for the resilience of the Dutch forest sector.

adaptivity Netherlands resilience risk uncertainty

K 5-7 (Konzerthaus Freiburg)

IUFRO17-4077 **Climate futures in place: Using interated collaborative scenario building for adaptive landscape governance**

Williams, D.* (1); Murphy, D. (2); Wyborn, C. (3); Yung, L. (3)

(1) US Forest Service, Rocky Mountain Research Station, Fort Collins, United States; (2) University of Cincinnati, Cincinnati , United States; (3) College of Forestry, University of Montana, Missoula, United States

Abstract: Three case studies are presented to show how local decision-makers address uncertainties in climate adaptation. Each case used an iterated collaborative scenario-building process to engage local stakeholders in discussions about the social, ecological, and climate interactions in three alternative futures. Based on our research and the literature, we posit that all adaptation decisions are challenged by three attributes: uncertainty, variability, and cross-scalar interactions. Drawing on our insight into the varied ways that planners and stakeholders express and act on uncertainty, variability, and scale, this paper examines the interactions between these attributes and the implications for adaptation forest governance. Comparison of the cases demonstrates a number of beneficial elements to this methodology. Scenario building was found to be a useful tool for enhancing adaptive capacity, dealing with climate uncertainties and represents a way to co-produce and incorporate experiential knowledge for natural resource planning. The scenario-building process enabled participants to pursue a future desirable state within certain parameters and in interaction with other local actors at various scales. This interaction permitted the identification of possible future disputes as well collaboration and constraints as well as opportunities. One of the remaining barriers to using collaborative scenario building practices as a collaborative forest planning practice in the US is that current public sector forest planning practice remains anchored in Newtonian model of knowledge creation and application, whereas planning for large scale landscape changes necessitates methodologies suited to complex adaptive systems that more effectively engage uncertainties and the co-creation of knowledge.

climate uncertainty, collaboration, governance

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99 - Adaptive spaces: can forest planning support innovative forest practice and knowledge co-creation

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1138 **Forest planning as a stick and a sermon: framing options for adaptation and innovation**

Brukas, V.* (1)

(1) SLU, Southern Swedish Forest Research Centre, Alnarp, Sweden

Abstract: The call of the session denotes that "Conventionally practitioners are seen as the recipients of knowledge from science, and implementers of decisions from planners". However, our earlier studies (e.g. Brukas and Salln äs 2012, Brukas et al. 2013) demonstrate that the practitioners' degrees of freedom differ significantly between countries. This is due to a number of factors such as the established forestry paradigms, professional ideology, and mixes of policy instruments. Forest planning is interwoven with these background factors and it can serve for operationalizing command-and-control approaches but it can also function as informational instrument without rigid prescriptions. The proposed presentation will illustrate such varying applications of planning by example of two European countries, Lithuania and Sweden. This will set framework for discussing the options that the different instrumentation of planning provides for coping with uncertainty and fostering innovation by forestry practitioners.

Policy, management planning, decision freedom

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1941 **Adapting natural resource management to climate change through science-management partnerships**

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(1) University of Washington, School of Environmental and Forest Sciences, Seattle, United States; (2) United States Forest Service, Seattle, United States

Abstract: Concrete ways to adapt to climate change are needed to help natural resource managers take the first steps to incorporate climate change into management and take advantage of opportunities to balance the negative effects of climate change. We recently developed several local and regional-scale science-management climate change adaptation partnerships with national forests, national parks and other stakeholders in the western United States. Goals of the partnerships were to: (1) synthesize published information and data to assess the exposure, sensitivity, and adaptive capacity of key resource areas, including water, fisheries, vegetation, disturbance, wildlife, cultural heritage, recreation and ecosystem services; (2) develop science-based adaptation strategies and tactics that will help to minimize the negative effects of climate change and assist the transition of biological systems and management to a warmer climate; (3) ensure adaptation strategies and tactics are incorporated into relevant planning documents; and (4) foster an enduring partnership to facilitate ongoing dialogue and activities related to climate change in the partnerships regions. After initial vulnerability assessments by agency and university scientists and local resource specialists, adaptation strategies and tactics were developed in a series of scientist-manager workshops. The final vulnerability assessments and adaptation actions are incorporated in a series of peer-reviewed technical reports. The partnerships produced concrete adaptation options for national forest and other natural resource managers and illustrated the utility of scientist-manager workshops in adapting to climate change.

adaptation, climate change

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2967 **Role of local knowledge in community forest management: the case of idundakiyave miombo woodland, Tanzania**

Bala, P. (1); Bala, P.* (2); Musinguzi, P. (1); Lund, J. (1); Meilby, H. (1); Chomba, S. (3)

(1) University of Copenhagen, Copenhagen, Denmark; (2) Kenya Forestry Research Institute, Kitui, Kenya; (3) Centre for Evidence-Based Development in Africa, Nairobi, Kenya

Abstract: Technical Forest Management Plans (TFMP) are popular in Participatory Forest Management (PFM) systems.They are often flawed,costly,and rarely used to inform practices. They partly contribute to delayed decentralization of use right to locals.Information on the potentials of local knowledge as alternatives to TFMP under PFM is scanty.This study sought to explore local forest managers' understanding of changes and trends in Miombo woodland condition;ecology,practices and biophysical outcomes of PFM. Qualitative and quantitative methods were used. Results indicate that local forest managers possess some ecological knowledge similar to those scientifically documented.Their understanding of changes in forest condition has evolved into simple monitoring techniques on the status of most valued tree species and some divergent indicators of change in forest condition. However, their understanding of forest stock was scanty and less reliable. Consequently,actual harvest was less than experts' estimates, which partly explains the conservation success while undermining the livelihoods of some users.This study points to the potential of local participation in developing simple and reliable monitoring techniques but calls for integration of local and expert knowledge to determine annual allowable cut for sustainable forest management.

Community, PFM, local knowledge, biophysical

All Division 4 (Forest Assessment, Modelling and Management) Meeting

9 - IUFRO Task Force on Biological Invasions in Forests

K 5-7 (Konzerthaus Freiburg)

IUFRO17-844 **Ideal versus Real forest management: a novel approach for applied cross-disciplinary research in forest science**

Lodin, I.* (1); Brukas, V. (1); Sallnäs, O. (1); Mozgeris, G. (2)

(1) Southern Swedish Forest Research Centre, SLU., Alnarp, Sweden; (2) Institute of Forest Managment and Wood Science, ASU., Akademija, Kaunas region, Lithuania

Abstract: Silvicultural research, operative guidelines and legal prescriptions often focus on ideal management schemes that aim to "guide" a forest stand towards the fulfilment of explicitly or implicitly defined objectives. However, based on empirical data it is evident that substantial cohorts of forest owners or managers do not follow the prescribed ideals, resulting in substantially different forest management outcomes in practice. Investigating this divergence can highlight areas characterised by conflicting interests or implementation deficits, where policy makers might be tempted to intervene and steer the forest management behaviour in a desired direction. It also constitutes an interesting arena for cross-disciplinary research that would contribute to a better understanding of the various factors shaping forest management practices. In our paper we provide a conceptualisation of ideal and real forest management, geared towards defining a scientific agenda for future applied research that qualifies and quantifies this dichotomy. We also illustrate our conceptual elaborations by examples from Lithuania and Sweden, two European countries that are characterised by markedly different socio-economic developments and forest management traditions.

forestry paradigms, policy, management practice

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187 - Remote Sensing in Carbon Balance Evaluation and Monitoring

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1414 **Unravelling uncertainty - Combining forest cover change products and biomass datasets in the context of REDD+**

Bos, A. B.* (1); Avitabile, V. (1); De Sy, V. (1); Duchelle, A. E. (2); Herold, M. (1)

(1) Wageningen University & Research, Laboratory of Geo-Information Science and Remote Sensing, WAGENINGEN, Netherlands; (2) Center for International Forestry Research, Climate Change and Energy, BOGOR, Indonesia

Abstract: To measure the effectiveness of efforts to reduce emissions from deforestation and forest degradation (REDD+), one requires data on both forest cover (change) and biomass stocks. Regional to global datasets with increasing levels of coverage, spatial and temporal detail, and accuracy stem from innovations in remote sensing and forest monitoring. Still, these datasets do not necessarily align with each other, and it remains unclear how their uncertainties influence carbon emission estimates.

Our study area covers six REDD+ subnational initiatives in five countries across the tropics. We compared approaches to quantifying impacts on carbon emissions. We performed an accuracy assessment on the activity data using several tree cover change datasets such as locally calibrated products based on dense time series data and a global dataset on annual tree cover change. For the error estimation, we used validation tools for human interpretation based on Landsat Time Series data and high resolution optical imagery. Next, we calculated carbon emission estimates based on pantropical biomass maps and field inventory data. We differentiated emissions from before and after the start of the REDD+ initiatives and also considered control areas to estimate REDD+ impact.

We found that forest change products based on locally calibrated algorithms had a higher accuracy than the global product assessed. Biomass datasets built on both remote sensing and local field inventory data led to better carbon emission estimates. REDD+ impact was limited but varied considerably between initiatives. Still, the choice of datasets and assessment methods had an influence on the measured local and regional REDD+ performance. This study contributes to carbon measurement, reporting and verification by providing insight into what extent both activity data and biomass data influence the uncertainty of carbon emission estimates.

REDD+;MRV;carbon;biomass;deforestation;uncertainty

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1839 **Uncertainty analysis on the carbon and water balance of Boreal forests using a process-based model driven by satellite images**

minunno, F.* (1); Sirro, L. (2); Mutanen, T. (2); Aurela, M. (3); Häme, T. (2); Liski, J. (3); Vesala, T. (1); Mäkelä, A. (1)

(1) University of Helsinki, Helsinki, Finland; (2) VTT Technical Research Centre of Finland , Espoo, Finland; (3) FMI, Helsinki, Finland

Abstract: Earth Observation (EO) data can potentially be used to drive vegetation models and monitor carbon and water fluxes over large areas. However there might be a high degree of uncertainty in model outputs due to uncertainties in the initial state variables (ISV) from EO and model parameters (MP).
We studied the propagation of uncertainty caused by ISV and MP through a forest model to the outputs. We used a carbon-balance based growth model combined with a soil carbon model. The model was previously calibrated by means of Bayesian statistics and then tested at two eddy sites. Stand variables derived from LANDSAT images at 20m resolution were used to initialize the model.
We used canonical correlation analysis to identify which model inputs (ISV and MP) were mainly responsible for the predictive uncertainty.
The main conclusions were: (1) The bulk of the uncertainty was caused by initial basal area and stand height derived from EO, and those variables most dependent on EO were the most uncertain. Because of this, the largest uncertainty was associated with mean annual increment, while the smallest uncertainty was related to evapotranspiration. (2) The uncertainties were larger in the beginning of the simulation and reduced as time elapsed, owing to the fact that the influence of the initial state was reducing with time. However, we did not consider the correlation of errors between the input components, therefore probably creating more overall uncertainty to the outputs. It is noteworthy that the uncertainty of predictions over large areas is much less than that of individual grid cells.
On this basis, we discuss the opportunities and challenges of using EO data for large scale simulations with the aim of monitoring carbon and water fluxes.

PBmodelling, EO, C&W balance, uncertainty analysis

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3295 **Modeling Carbon Balance in Polish Forests Using Canadian CBM-CFS Software and Remote Sensing.**

Balazy, R.* (1); Waraksa, P. (1); Mróz, B. (1); Korzeniewski, K. (1); Zawila-Niedzwiecki, T. (2)

(1) Forest Research Institute, Raszyn, Poland; (2) Warsaw University of Life Sciences , Faculty of Forestry, Warsaw, Poland

Abstract: Modeling carbon balance constitutes a significant challenge even for modern - precise forestry. Increased related profits, and particularly the greater impact of climate changes result in an urgent need to develop effective tools for its monitoring. For a few years, State Forests in Poland have been successfully adjusting to their needs the Canadian CBM-CFS software, which serves for the purpose of modeling carbon balance. Although they have a very detailed and state-of-the-art system of spatial information and a detailed database at their disposal, also in this case, the need for using remote sensing for making results more specific is noticeable.
The presentation will include the so far Poland's experience in the implementation of CBM-CFS software for the purpose of carbon modeling in forests, supported by the use of satellite imaging or aerial laser scanning.

Carbon balance modeling, satellite, LiDAR, CBM-CFS

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187 - Remote Sensing in Carbon Balance Evaluation and Monitoring

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3089 **Dynamics of mangrove above ground carbon stocks estimated with Landsat time series and field data in J. N. "Ding" Darling National Wildlife Refuge, Florida.**

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(1) USGS , Reston, United States; (2) Boston University, Boston, United States

Abstract: Mangrove wetlands throughout the world have been associated with high Carbon storage capabilities; yet, considerable variation exists globally in estimated rates of carbon sequestration in surveyed mangrove ecosystems.
The focus of this research is to develop a scientifically rigorous methodology for continuous monitoring of mangrove ecosystems and estimates of aboveground carbon storage.
Our proposed methodology integrates field data, remote sensing, and modeling to monitor and estimate the amount of carbon stored in mangrove ecosystems and to create a baseline for future carbon sequestration estimates and forecasting in Ding Darling National Wildlife Refuge, Florida, USA.
This presentation is focused on 1) the sampling design developed for aboveground biomass estimates; 2) field work implementation with aboveground carbon storage estimates based on existing allometric equations developed specifically for mangrove species found in Florida; 3) area and change estimates from the continuous classification and change detection (CCDC) technique for 1986 -2016 using Landsat, and 4) results from extrapolating the ground data to the entire refuge area using Landsat and high resolution data.
This study serves as a pilot project to develop a methodology that can be applied to other carbon-rich mangrove environments, thus enhancing coastal resilience to climate change effects.

Mangroves, Carbon, Field data, Landsat Time Series

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1227 **Above Ground Biomass Estimation using Synthetic Aperture RADAR (SAR) in Mount Makiling Forest Reserve, Philippines**

Dida, J. J.* (1); Bantayan, N. (2); Tiburan Jr., C. (1); Lapitan, R. (1)

(1) Institute of Renewable Natural Resources, College of Forestry and Natural Resources, Los Baños, Laguna, Philippines; (2) Makiling Center for Mountain Ecosystem, College of Forestry and Natural Resources, Los Baños, Laguna, Philippines

Abstract: The Mount Makiling Forest Reserve (MMFR) is home to a diverse and unique species of plants, rare and endangered species of fauna. Given the roles of forest in sequestering atmospheric carbon, the estimation of above ground biomass (AGB) will help in the evaluation of future conditions of MMFR. The advantages of using remotely sensed data such as Synthetic Aperture Radar (SAR) is that it allows repetition of data collection that allows fast processing of large quantities. The objective of the study is to investigate the potential use of SAR in AGB estimation of the long-term monitoring plots inside the MMFR. The backscatter values of HV, HH, HH/HV polarization were generated from a 25 m ALOS PALSAR mosaic dataset and compared with the field AGB estimates. The correlation and linear regression showed that there is a moderate to strong relationship between radar backscatter and biomass estimates but low coefficient of determination. The use of smaller subplot areas in the regression analysis did not improve the coefficient. The study nevertheless showed that SAR data can be utilized to estimate AGB especially in large areas where field survey is costly. Furthermore, additional monitoring plots will be useful in the improvement of estimation using this technology.

Biomass Estimation, PALSAR, Makiling, Backscatter

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1866 **Mapping growing stock volume and biomass of larch plantations in Northeast China with L-band ALOS PALSAR backscatter mosaics**

Gao, T.* (1); Zhu, J. (1); Yan, Q. (1); Deng, S. (2); Zheng, X. (3); Zhang, J. (1); Shang, G. (1)

(1) Institute of Applied Ecology, Chinese Academy of Sciences, Qingyuan Forest CERN, Chinese Academy of Sciences, Shenyang, China; (2) Institute of Mountain Science, Shinshu University, Nagano 399-4598, Japan; (3) Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, China

Abstract: The reliable estimates of growing stock volume (GSV) and biomass are critical for making management strategies of plantation forests. This study integrated L-band SAR (Synthetic Aperture Radar) data with ground-based inventory, and developed empirical models to map GSV and biomass of larch (Larix spp.) plantations (LPs) in Northeast China (ca. 1.24 million km2). The optimum model presented GSV evaluation in terms of root mean square errors was 33.1 m3 ha-1. The total GSV and biomass were estimated to be 224.3 ± 59.0 million m3 and 113.0 ± 29.7 TgC (1 Tg = 1012 g), respectively, over an area of 264 million ha in 2010. The saturation effects of L-band SAR at GSV levels was beyond 210 m3 ha-1, which could be expected to influence the estimates for a quite small proportion of the study area. However, the estimation accuracy has limitations due mainly to uncertainties in LP mapping, SAR data and sampling errors. Considering current China's timber supply and growing environment threat, the LP's non-timber service priorities should outweigh its timber values, and thus the corresponding spatial pattern planning of services priority and forest management practices should be carried out to assure broader and sustainable benefits from LP in future.

larch plantation; growing stock volume; L-band SAR

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172 - International compatibility and benchmarking of economic data from monitoring, reporting and

K 1 (Konzerthaus Freiburg)

IUFRO17-2155 **Business analyses comparation of selected forest companies in South East Europe**

Posavec, S. (1); Keca, L.* (2); Pezdevsek Malovrh, S. (3); Delic, S. (4); Stojanovska, M. (5)

(1) Faculty of Forestry University of Zagreb, Zagreb , Croatia; (2) University of Belgrade, Faculty of Forestry, Belgrade, Serbia; (3) University of Ljubljana, Biotechnical Faculty, Ljubljana, Slovenia; (4) University of Sarajevo, Faculty of Forestry, Sarajevo, Bosnia and Herzegovina; (5) University of Skopje, Faculty of Forestry, Skopje, Macedonia, the former Yugoslav Republic of

Abstract: Specific aspects of forestry as economic activity create certain problems in implementation of business plans and financial calculations. Particularity of forest management can be noticed in long-term cycle of biomass production, long time period from initial work to accomplishing economic effects, as well as in large forest investment needs, many times larger than forest owners' financial possibilities. Using the business analysis, parameters that indicate forecast of future business trends will be compared. Comparative financial reports are basis for execution of horizontal balance sheet and profit and loss account analysis. In this paper, benchmarking and comparative analysis of business indicators from financial reports (such as balance sheet, profit and loss account, profitability and cost-effectiveness) of state owned forest management companies in Croatia, Serbia, Slovenia, Bosnia and Herzegovina and Former Yugoslav Republic of Macedonia will be shown. All companies that were chosen and analyzed on the basis of management scope and production share are in state ownership. Some countries have several state owned forest management companies, so the companies with the largest covering area, employment capacity, profit and annual cut were chosen. Analyzed companies follow the principals of sustainable management, thus supporting social, economic and ecological function of forestry in the region.

business indicators, benchmarking, profitability

K 1 (Konzerthaus Freiburg)

IUFRO17-2269 **Benchmarking based on typical farm data: What forestry may learn from agri benchmark Cash Crop**

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(1) agri benchmark Cash Crop, global networks, Braunschweig, Germany; (2) Thünen-Institut Intern. Waldwirtschaft & Forstökonomie, Hamburg , Germany

Abstract: In a globalized world, in-depth knowledge of the different country-specific framework conditions, the resulting operations and management strategies and finally the economics of these different systems is essential. In order to get there, one needs a harmonized approach for all participating countries and a global uniform data base.
Usually it is not feasible to generate such information based on large sample sizes because gathering such in-depth data is rather costly, agri benchmark Cash Crop therefore developed the concept of "typical farms" which is applied in about 50 countries for more than a decade. Based on a standard operating procedure scientists around the world - including countries without any meaningful official statistics - are collecting and sharing such information on crop production systems and their economics. The aim is to provide strategic insights to stakeholders from industry, policy and development agencies.
The paper will provide a systematical overview over the concept of agri benchmark and based on that explore options to apply it in global forest production.

benchmarking, production economics, forestry

K 1 (Konzerthaus Freiburg)

IUFRO17-2456 **Optimizing forest value chains in northern Norway to strengthen regional resource usage and value creation**

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(1) NTNU, SINTEF, Trondheim, Norway; (2) SINTEF, SINTEF, Trondheim, Norway

Abstract: As a consequence of past decades' extensive afforestation in Norway, mature forest volumes are increasing. National forestry politics aim call for sustainable and efficient resource usage and for increased regional processing. Regional policies seek to provide good conditions for such industries to be competitive and to improve regional value creation. We discuss how methods from regional macro-economics, operations research and social sciences may complement each other to support decision makers in this process. Operations research is concerned with finding an optimally designed wood value chain and an aggregated planning of its operations, taking a holistic perspective on a strategic-tactical level. Based on statistics and survey data, input-output analysis can estimate the sector's value creation and impact on society beyond the immediate value chain activities. Combining these approaches in a common mathematical optimization model, a balance is struck between industry / business and political interests. This helps to assess effects of political measures and business conditions on the regional economy and on industry activities. Network analysis identifies relations between important entities within and outside the wood value chain, determining drivers and barriers for adopting good solutions.

Wood value chain, optimization, regional economics

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148 - Innovative value added chains in forestry

K 1 (Konzerthaus Freiburg)

IUFRO17-3892 **Innovative non-wood forest products economies explained through their network structure: failure or success?**

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(1) University of Padova, Legnaro (Padova), Italy; (2) European Forest Institute, Joensuu , Finland

Abstract: Local communities may generate new income options through the use of Non-Wood Forest Products (NWFP). Associations, entrepreneurs, public authorities and other private and public organizations are able to create added value from NWFP through either a market approach focused on supply chains innovation or a governance approach based on adaptation of the regulative system. Both of these approaches require a network structure that fosters cooperation and coordination among involved stakeholders.
Which are the network structures that help a successful management of NWFP-based innovation? The paper analyses eight "in depth case studies" (IDCS) in different European countries, on the basis of the research activities carried out within the StarTree project. Each IDCS, characterized by different market tools and regulations system, has been considered innovative by local experts; but not all of them succeeded in creating added value for local communities. IDCS differ by number and type of actors, by the contractual links and social ties, by formal or informal relationships. These relations have been analysed through the use of selected indices of Social Network Analysis related to the structural social capital theory. The study demonstrates that the overall network structures with strong small-world characteristics help to create added value at local level. Results show different types of successful network organizations that have been interpreted both in term of the efficiency of the whole network and as a result of the role played by single leading actors with relevant market or political power.

Social Network Analysis, Social Capital, NWFP

K 1 (Konzerthaus Freiburg)

IUFRO17-3583 **Climate friendly harvest scheduling in boreal forests of Finland**

Sievänen, R.* (1); Salminen, O. (1); Kallio, M. (1); Kalliokoski, T. (2); Kuusinen, N. (1); Berninger, F. (2); Vanhatalo, A. (2); Bäck, J. (2); Taipale, D. (3)

(1) Natural Resources Institute Finland, Helsinki, Finland; (2) University of Helsinki, Department of Forest Sciences, Helsinki, Finland; (3) Unversity of Helsinki, Department of Physics, Helsinki, Finland

Abstract: The boreal forests cover three fourths of the land area of Finland. About 80 per cent of the total forest area is managed for commercial forestry. The forests produce timber for wood processing and pulp and paper industries and provide also bioenergy. The harvests of timber vary depending on demand of products of forest industry; the harvest level has been on average about 70 per cent of growth in recent years. The climate impact assessments of regional forest use have mainly targeted carbon and assumed that the operations (timing, intensity of thinning, and length of rotation in the first place) are applied as is done in the commercial forestry.

Carbon is the most important but not the only constituent of climate impact of forests. We have implemented in a framework of a forest carbon model that combines a large-scale forestry model, the soil carbon model Yasso07 for mineral soils, and a method based on emission factors for peatland soils also the effect of forest structure on albedo and secondary organic aerosols. This makes it possible to evaluate the effect wood use on different components of forest climate impact.

In the analyses forest management planning of commercial forestry, the target is usually to maximize the net present value of cuttings and it has most often been used also in the analyses of forest carbon. Here we present results of 50-year scenarios pertaining to a region in Finland in which the target of optimization is climate impact or its components. We apply two scenarios of wood demand (timber and bioenergy) that the harvest schedules need to meet in addition to optimizing the climate target. We compare the forest structure created by different optimization targets and levels of wood use and make conclusions about the possibilities of applying climate friendly harvesting in Finland.

forest, climate impact, carbon, albedo, aerosols

K 1 (Konzerthaus Freiburg)

IUFRO17-874 **Market-level implications of regulating forest carbon storage and albedo for climate change mitigation**

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Abstract: Increasing forest carbon storage is one way to mitigate climate change. Increased storage can be encouraged by subsidizing removals and taxing emissions. Pricing these fluxes according to the Social Cost of Carbon (SCC) has been proposed as a way to attain socially optimal storage. However, increasing storage means increasing forest area or density, both of which make Earth's surface darker (i.e. reduce the mean annual albedo of the landscape). Dark surfaces absorb more solar radiation than light ones and, therefore, have a stronger warming impact on the atmosphere. This "albedo effect" is especially large in areas with seasonal snow cover. To optimize the climatic impacts of forestry, it is therefore necessary to regulate two externalities (carbon and albedo) instead of just one (carbon). We explain how a forest carbon subsidy system could be extended to include albedo, and we analyze the market-level implications of implementing such a policy. We show that regulating both externalities reduces the socially optimal level of carbon storage in forests, compared to regulating carbon only. The market-level framework allows us to account for the land allocation effects of albedo regulation, which are not included in previous (stand-level) studies.

carbon, albedo, externality, climate, regulation

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39 - Beyond Carbon: REDD+ implementation in the local level

KG I - 1015 (Uni Freiburg)

IUFRO17-2101 **REDD+ activities at the local level - Lessons from community managed forests in the Heart of Borneo**

Damayanti, E. K.* (1); Berry, N. (2); Fehse, J. (3)

(1) Bogor Agricultural University, Daemeter Consulting, Bogor, Indonesia; (2) LTS International, Nr. Edinburgh, United Kingdom; (3) Value For Nature Consulting, LTS International, Oxford, United Kingdom

Abstract: Two communities in the Heart of Borneo (HoB) have been starting to manage forests in their areas. Objective of this study is to understand how communities develop, implement, and monitor activities in the REDD+ context. Several village meetings and key informant interviews were held in each community. Results show that forests have become their livelihood, but the communities did not have knowledge on how to legally manage the forests. Some interactions with external parties, such as local and international NGOs and international institutions have made communities aware and understood their rights over forest, relate their livelihood to the forest management schemes, and finally started to formalize management of surrounding forests. During facilitation by authors, REDD+ concept were communicated in a very simple way, using the examples of communities' livelihood, forest ecosystem services, and how to maintain the forests so that communities can utilize the forests over generations. Communities planned land uses and specific activities for each land use. In both communities, legal forest management rights and development of village regulation on forests are required enabling conditions for sustainable use and management of the forests. Forest management activities and monitoring schemes were planned, e.g. forest boundary demarcation, tree planting activities, forest patrol, and ecotourism. Experiences in these two villages can therefore help inform the development of community-led REDD+ and payments for ecosystem service projects in community managed forests (e.g. village forests, customary forests and territories, and other types of social forestry areas) throughout the Heart of Borneo.

community, livelihood, forest services, REDD+, HoB

KG I - 1015 (Uni Freiburg)

IUFRO17-1352 **Beyond carbon: a look on community-based forest conservation approach at a sub-national REDD+ demonstration site in the Philippines**

Veridiano, R. K.* (1); Tumaneng, R. (2); Pales, J. R. (3); Monzon, A. K. (4); de Alban, J. D. (5)

(1) Johann Heinrich von Thünen Institute , Institute of International Forestry and Forest Economics, Hamburg, Germany; (2) PCIEERD, Department of Science and Technology, Taguig , Philippines; (3) National Mapping & Reource Information Authority, Taguig, Philippines; (4) Department of Geography, University of Cambridge, Cambridge, United Kingdom; (5) Department of Biological Sciences, National University of Singapore, Singapore, Singapore

Abstract: In a country where participatory involvement of different stakeholders is the norm, we have come to learn how to translate numbers and data into a language that communities and policy makers alike would understand. Much has been done since the inception of REDD+ in the Philippines as part of a larger framework for its implementation. Case in point is the Victoria-Anepahan REDD+ demonstration site located in Palawan province. This study highlights the importance of ensuring that communities of indigenous peoples (IP) play an integral part in every component of REDD+ implementation. Through a series of training workshops and fieldwork, we were able to train and develop capacities of 97 participants (76% of which are IPs), of whom eventually gained a step-wise understanding of various REDD+ concepts as well as an appreciation of the results of biodiversity and carbon assessments. Together with the partner IP communities, we're able to estimate that the sub-national REDD+ site currently harbours a baseline forest reference level of 11.20 ±1.37 Mt CO2eq/yr. The mean biomass estimate (254.99 t/ha) generated by the study conforms to the default values at the national (227.40 t/ha) and sub-national (297.51 t/ha) scales. Yet, the story does not end with them having understood these concepts. Equipped with this new knowledge, local IPs together with policy makers from the provincial government initiated the establishment of a community-managed watershed reserve, ratified through a local ordinance and demarcated on the ground. Such actions and initiatives further demonstrate the indigenous peoples communities' capacity to act upon science-based assessments and translate them into conservation policies that promote better management and conservation of the remaining forests of Palawan, Philippines.

IP community, capacity-building, REDD+

KG I - 1015 (Uni Freiburg)

IUFRO17-2048 **Expectation and Disappointment: the social life of expectations in REDD+ pilot projects in Tanzania**

Massarella, K.* (1); Sallu, S. (2); Ensor, J. (3); Marchant, R. (1)

(1) University of York, York, United Kingdom; (2) University of Leeds, Leeds, United Kingdom; (3) Stockholm Environment Institute, York, United Kingdom

Abstract: The management of stakeholder expectations is highlighted as an important issue by practitioners of forest conservation and development pilot projects, particularly in relation to REDD+. Yet very little is known about how expectations function on the ground, or what their outcomes are. Through analysis of narratives from a wide range of international to local stakeholders about their experiences of REDD+ pilots in Tanzania, and insights from the sociology of expectations literature, this study investigates the 'social life' of expectations. It explores causes of expectations, how they develop on the ground and are framed by different stakeholders, and their outcomes, with many actors identifying a cycle of expectation and disappointment. It finds that expectations behave as both cause and outcome of piloting activity; that they are framed differently by different stakeholders depending on personal, social and external factors, making them highly unpredictable; and that the 'social life' of expectations continues after the pilot project itself has finished. As such, this paper advocates a more in-depth and nuanced discussion of expectations among practitioners. This includes acceptance that expectations are an important part of people's experience, yet their inherent unpredictability makes them hard to manage in pilot projects like REDD+.

Expectations, pilot projects, REDD+, Tanzania

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39 - Beyond Carbon: REDD+ implementation in the local level

KG I - 1015 (Uni Freiburg)

IUFRO17-1962 **Tailormade solutions for tenure security in REDD+ and community conservation projects**

van der Zon, M.* (1); de Jong, W. (2); Arts, B. (3); Boot, R. (4)

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Abstract: In the 1990s, economists, influenced by historians and anthropologists, started to recognize that tenure security as perceived by local actors is what influences their choices regarding investing in their land and its resources. While land titles can contribute to this perceived tenure security, the local historic contexts as well as social, economic and power-related elements are at least as important for land use choices, including conservation. By providing empirical evidence, this paper indicates that tailormade bottom-up approaches to tenure security in forest communities positively impact on results of REDD+ and conservation projects. Such approaches take into account existing local realities, with their unique traditions, norms, values, and economic and other interests when designing and implementing tenure arrangements. The conclusions are based on a series of case studies that pursue alternative approaches to provide tenure security used in the Peruvian Amazon, including local conservation areas, conservation or ecotourism concessions, private conservation areas, and conservation agreements. As part of our analysis we bring to light weaknesses of the current dominant focus in REDD+ projects on communal land titles as a 'one-size-fits-all' solution, and comment on how more flexible bottom-up approaches can help mitigate these.

tenure, communities, REDD+, conservation

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IUFRO17-873 **How to achieve effective participation of communities in the monitoring of REDD+ projects in the Democratic Republic of Congo (DRC)**

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Abstract: The UNFCCC REDD+ mechanism requires national schemes for carbon measurement, reporting and verification and safeguard information systems for non-carbon benefits. Locally, REDD+ projects need to establish monitoring systems in line with the aspired project certification. In this context, community-based monitoring (CBM) is proposed as a complementary approach to remote sensing and expert-based monitoring. In the Congo Basin region, the Democratic Republic of Congo (DRC) is the most advanced country in implementing REDD+ projects but CBM is little developed. The objective of this study was to prepare recommendations for the integration of CBM in REDD+ monitoring in the DRC based on a Delphi survey. Out of 65 national and international experts selected for their expertise in REDD+ and CBM in DRC and elsewhere, 35 agreed to participate in the study; 19, 17 and 14 feedbacks were received from the first, second, and third Delphi round respectively. The results revealed consensus amongst panelists that community members can monitor carbon and non-carbon benefits. The panelists stressed the importance of community participation in all steps of the monitoring process, while capacity-building activities must be in place. The findings support REDD+ projects and the national REDD+ coordination in defining the role of communities in REDD+ activities in the DRC.

community monitoring, Delphi study, safeguards

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IUFRO17-729 **Assessing community capacity for MRV activities at pilot project level: comparison analysis from case study of Rwanda, Cameroon and DRC.**

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Abstract: To measure the socioeconomic benefits from forests, data collection must focus on people, not only trees. But also to assess forest resources for REDD+ project initiatives the exercise has to be done not only by scientist from university but mainly by local people using thus the local knowledge to monitor forest resources. The assessment and monitoring doing by local people is not only cost-effective and time-saving but also allow the implication of beneficiary community. Many research conclude But community capacity was generally found to be insufficient for meaningful uptake and implementation MDP or REDD+ mechanism. At the level of a local pilot project does the local community has all requirement and skills to carry out MRV activities? Using the community capacity assessment framework, we evaluate the community capacity on implementing and monitoring a MRV activities in three Rwanda, Cameroon and DRC. Based on the criteria like planning, coordination, and management abilities we investigated on the local skills, community knowledge, and local social organisation that are needed for collecting, analysing, reporting and monitoring forest resources. Our study reveals that the local context of countries influence hardly on the implementation process. Furthermore skills and local knowledge are more developed in the forest zone (Cameroon); in contrary organisational capacities are more in degraded context like west DRC and Rwanda. National REDD+ processes can learn on the local experiences of local pilot project to build national mechanism.

MRV, local community, pilot project, forest

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IUFRO17-1568 **Spatio-temporal analysis of accessibility of urban forest: An analysis on Tohoku region, Japan**

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Abstract: The accessibility of urban forest depends on the distribution of population and landcover change. Urban forests need managements to balance the conservation of urban biodiversity and recreational use which contribute to the quality of life. In the process of sub-urbanization mostly with population increase, amount of urban forests tend to decrease, yet, the forests with high accessibility can increase simultaneously. In the process of shrinking with depopulation, as with nested in Japanese cities, amount of urban forests can gradually increase and the forests with high accessibility can be maintained. However, aging of urban residents will proceed, and the aged residents have difficulty in maintaining adequate managements of the urban forests. By analyzing those spatio-temporal trends, urban issues in future can be identified, and it can contribute to developing the efficient policies and activities of urban forest managements. In this research, we analyze a Japanese city that are moving to depopulation trend, and provide scientific platform to develop the strategies in era of shrinking. The districts with depopulation do not occur uniformly in a municipality area, the managements of districts level with long term perspectives are required.

Urban forest, accessibility, population, landcover

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IUFRO17-745 **Managing ecosystem commons - Attitude toward environmental consideration among Swedish forest owners based on a forest owner typology.**

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Abstract: Management of common ecosystems is an important challenge for policy makers. Especially the forest is a vital provider of ecosystem services. In Sweden, forest cover about 57 per cent of total land area, and is one major provider to the local economy. About half of the forest land is owned by non-industrial private forest owners, while the rest is owned by forest companies or the government. Swedish forest policy generally written according to the so-called Swedish Forest Model which means that the forest owners, regardless of ownership structure, have the freedom but also the responsibility, to manage their forest to fulfill the general consideration paragraph. The policy thus increased the demand of more competence of the forest owner in terms of knowledge of e.g., environmental consideration. The policy system does not incentivize forest owners to take consideration and there are no penalties for owners who do not fulfil the goals and investigation shows that consideration has decreased. It seems that forest policy is failing, as the environmental goals are not reached. The question is why is policy not successful? One question, not previously researched, is how forest owner's attitudes and values affect their behavior toward environmental consideration. In a recent postal survey directed to 3000 non-industrial private forest owners (the largest ownership group in Sweden), questions on attitudes and values aims at evaluating the Swedish forestry model. A first step, presented in this paper, is to understand the motivation behind forest ownership. In the forest ownership typology, we found three distinct motivations driving forest ownership: economic, consumption and protection goals. Within these three categories we found five ownership types. There typologies can further be used in future research explaining attitudes and values in relation to environmental consideration, social and recreational values, as well as general attitudes to Swedish forest policy.

NIFP-owners, Swedish forestry model, survey

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IUFRO17-2920 **The influence of agricultural concessions on local community life in peat land areas in Riau, Indonesia**

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Abstract: In Indonesia, where 80 million people are economically dependent upon forests, the national government is attempting to balance economic development with the concerns of local residents. The long-term residents of Lukun village of Indonesia's Riau province depend upon sago palm production in peat swamps. However, devastation of these swamps for large scale development by companies under concession creates conditions which threaten local agricultural livelihoods as well as land disputes. In this research, we attempt to clarify (1) the effect of concessions on local people and (2) the problem of concession permission. Interviews with local people and NGOs reveal that nearby construction of canals for plantation development has lowered the water level of the peat swamp at Lukun village, rendering cultivation of sago palm more difficult for local residents. Analysis of documents indicates that the development next to Lukun village was legally undertaken under a concession issued by the Ministry of Forestry in 2009, meaning that the local government couldn't intervene to address this problem. We argue that it is necessary for the government of Indonesia to give permission for concession in peat swamps with consideration for not only the concession area but also the lives of residents in surrounding villages.

Indonesia, peat land, conflict, forest fire,

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IUFRO17-522 **Vulnerability of rural communities to climate change in the Gambia: influence of methodological approaches on assessment outcomes**

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Abstract: Climate change has become a major concern globally, particularly to rural communities who have to find rapid coping solutions. Several vulnerability assessment approaches have been developed in the last decades. This comes along with higher risk for different methods to result in different conclusions thereby making comparisons difficult and decision making non-consistent across areas. We assessed vulnerability of farmers to climate change in the North Bank Region of the Gambia. Twenty four indicators reflecting vulnerability components: (exposure, sensitivity, and adaptive capacity) were selected for this purpose. Data were collected through household surveys and key informant interviews. One hundred and fifteen respondents were surveyed across six communities and two administrative districts. Results were compared over three computational approaches: the maximum value transformation normalization, the z-score transformation normalization, and simple averaging. Regardless of approaches used, communities that have a high exposure to climate change and extreme events were the most vulnerable. Furthermore, vulnerability was strongly related to the socioeconomic characteristics of farmers. The survey evidenced differences in vulnerability among communities and administrative districts. Comparing output across approaches, overall, the study area was found to be highly vulnerable using the simple average and maximum value transformation, whereas it was only moderately vulnerable using the z-score transformation approach. We suggest that assessment approach-induced discrepancies be accounted for in international debates to harmonize/standardize assessment approaches to the end of making outputs comparable across regions. This will also likely increase relevance of decision making for adaptation options.

Vulnerability, Maximum value, Z-score, Averaging

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IUFRO17-302 **Landscape Image Sketching Technique for Forest studies**

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Abstract: To discuss different perceptions and interpretations of forests in a cultural framework, we proposed Landscape Image Sketching Image as an original, practical methodology. Utility of the methodology was tested through some cross-national researches, in which respondents were asked to make a landscape image sketch of an imaginary forest and to include keywords and text. The visual data were analysed from four aspects: 'linguistic knowledge', 'spatial view', 'self-orientation' and 'social meaning', which were represented by landscape elements, the shape of elements, the subject's standpoint and the combination of the elements in the framework.
As results, landscape image sketches revealed differences in characteristics between respondents in each nation. The results suggested a fundamental difference in ways of seeing the landscape through individual perceptions rather than normative views on forests. This methodology for visualising ways of seeing a landscape can be useful in understanding different assumptions about environmental issues, not only for a global environmental discussion regarding each locality, but also for local environmental management and public participation.

Landscape imagery, visual method

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IUFRO17-1848 **The socioeconomic impacts of large-scale tree plantations on local communities. Examining the empirical evidence.**

Malkamäki, A.* (1); D'Amato, D. (1); Hogarth, N. J. (1); Kanninen, M. (1); Pirard, R. (2); Toppinen, A. (1); Zhou, W. (2)

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Abstract: To meet increasing global demand for industrial roundwood, the area of large-scale tree plantations has expanded significantly during the last decades. Concerns about the long-term sustainability of this expansion, and the associated impacts on ecosystem services and local livelihoods have caused controversy among academics and practitioners. This systematic review synthesizes the available literature on the impacts of large-scale plantations on local communities, and identifies trends, bias and gaps in the empirical evidence base. All relevant literature was sought from scholarly databases and relevant organizational sources. Following screening and quality assessment, 115 individual studies underwent data extraction and synthesis. Results show no clear evidence that large-scale plantations are largely benefiting local people, however this may be partly due to a topical bias in the evidence base, with most studies focused on land use conflicts. However, there was some evidence of livelihood diversification and improved resilience, most likely due to recent improvements in plantation governance. Efforts for multi-stakeholder management of plantation landscapes should be encouraged, but to be successful these management schemes must be balanced, and suitable sustainability indicators used to monitor progress. In addition, terms of multi-stakeholder collaboration cannot be overly conditional or dictated by short-term economic or political interests.

Impacts; Planted forests; Systematic review

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IUFRO17-4152 **Village Forest Management Agreements (VilFoMA) as a performance-based payment scheme under REDD+ in Lao PDR**

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Abstract: The Climate Protection through Avoided Deforestation (CliPAD) program is a development project of the Lao Government supported by GIZ and(KfW). CliPAD supports the province of Houaphan to establish a provincial REDD+ program and provides incentives to local communities to participate in forest management and conservation efforts in village forest areas by engaging sub-national jurisdictions to develop and support strategies for reducing deforestation. The Village Forest Management Agreement (VilFoMA) scheme aims to regulate and promote sustainable management, protection and conservation of village forests. It intends to achieve this by establishing a legal basis and framework to link all village forest categories with international funding for climate change mitigation and channeling it down to the village-level through performance-based payments. Certain conditions need to be created and specific processes completed before VilFoMA can be enacted. Participatory Land Use Planning (PLUP) delineates forest and agricultural land while the Free, Prior and Informed Consent (FPIC) process involves awareness raising and the furnishing of consent to participate in the program are the initial preconditions. The village forest management planning process collects, collates and analyses data on forest resources, conditions and dynamics to create a Village Forest Management Plan which stipulates the specific management activities. The VilFoMA scheme is a framework covering all generalized contractual issues related to village forest management. It is a binding agreement between the village and district authorities which sets out the terms and conditions and outlines both parties' rights, benefits and the agreed incentive obligations in relation to village forest management and conservation. Adhering to the ViLFoMA will result in the sustainable use, protection and restoration of village forests and payments to incentivize participation and reward performance in these endeavors.

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IUFRO17-2534 **Spatial analysis of forest environmental tax as a scheme of Payment for Ecosystem Service: Suggestions to the REDD+**

Kohsaka, R.* (1); Uchiyama, Y. (1)

(1) Tohoku University, Sendai, Japan

Abstract: In this research, concepts for improving the scheme of REDD+ are provided by analyzing concrete facts and examples of forest environmental tax of Japan and other Asian region. The forest environmental tax is collected with other general taxes, and the revenue of the tax is used for the management of forest areas with social or environmental issues. The management areas are selected by the regional forest cooperatives with bottom up manner. Therefore it is not clear that the selections are appropriate to tackle with the issues of forest areas in wider regions. In this paper, result of analysis on the spatial correlation of distribution of management areas and social and environmental factors is provided. The result shows that the management areas overlap with the areas with high aging rates or natural hazard risks in a certain degree. To adequately manage the forest environmental tax, the spatial analysis of management areas with wider perspectives is required. By the analysis, the applicability of the concept of Payment for Ecosystem Service (PES) to REDD+ is analyzed. PES is a scheme for facilitating sustainable conservation of forest environment. The forest environmental tax is introduced as a scheme of PES in local level.

PES, forest environmental tax, REDD+, GIS

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IUFRO17-2535 **Schemes of Benefit Sharing in alternative livelihood strategies: potential of Geographical Indications of Non Timber Forest Products**

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(1) Tohoku University, Sendai, Japan

Abstract: The benefit from the conservation of forest environment and related biodiversity need to be shared with global and local stakeholders engaged in the conservation activities. Especially, local stakeholders can share the benefit through developing alternative livelihoods based on Non Timber Forest Products (NTFP) including beekeeping and mushroom production. However, there are NTFPs with relatively low economic value, and they cannot be used easily in alternative livelihoods strategies. To facilitate the conservation activities based on alternative livelihoods, other Benefit Sharing (BS) scheme need to be utilized in REDD+ areas. As another BS scheme, Geographic Indication (GI) is payed attention to. There are cases that GI applied to NTFPs, and GI facilitate BS in regional community that produce NTFPs. The BS scheme by GI can support the conservation activities in the region. In this research, issues and potentials of GI of NTFPs are discussed, and the requirements of BS schemes that can be applied to REDD+ are provided.

Alternative livelihood, NTFP, GI, ABS, REDD+

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IUFRO17-915 **Shifting Cultivation and REDD+ in Laos: Can the Village Development Grants deliver on stabilisation of shifting cultivation and CO2 emission reductions?**

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Abstract: The most recent estimate using satellite data estimated a total of 6,5 million ha of land under shifting cultivation in Laos. Ever since the independence in 1975, eradication of shifting cultivation - and later on its 'stabilisation' - has been the Government's most persistent policy. With the newest policy and institutional interventions, brought by the Reduction of Deforestation and Forest Degradation (REDD+), shifting cultivation was once again brought up as one of the main drivers of deforestation and forest degradation; and therefore an important concern for REDD+.

We use a case study approach, selecting SUFORD SU Project (Sustainable Forestry for Rural Development, Scaling Up - SUFORD SU) - financed by the World Bank and the Government of Finland - as a case. We particularly focus on Village Development Grants (VDG). The VDGs aim to contribute to emission reductions by addressing shifting cultivation and promoting permanent agriculture and other alternative livelihood options. Five years since the VDGs were distributed to targeted villages, the shifting cultivation seems to continue as earlier. However, no studies have examined the potentials of VDGs to address shifting cultivation and reduce CO2 emissions.

We analyse the potentials of VDG, as a REDD+ policy measure, to address shifting cultivation and CO2 emissions. In addition, we analyse the villagers' rationales for relying on this type of agriculture. We focus on ten villages; five of which are VDG beneficiaries. We use remote sensing data and satellite mapping in those ten villages to establish the effects of VDGs on shifting cultivation and CO2 emissions. To understand the extent to which communities have, or have not abandoned from shifting cultivation, as well as the reasons behind their decisions, we use socio-economic data and household interviews in four (out of 10 selected villages), two of which are VDGs beneficiaries.
*Study is in progress and no results to report yet. Will be on time for conferer.

Shifting cultivation, policy measure, CO2,REDD+

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IUFRO17-3678 **Are there differences between men and women's preferences for benefit sharing arrangements in REDD+ schemes?**

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Abstract: This paper presents the results of an assessment of benefit sharing arrangements in REDD+ projects in Indonesia, Peru and Tanzania. It focuses on three issues i.e. the satisfaction or dissatisfaction of men and women with benefit distribution arrangements, the factors that influence their satisfaction or dissatisfaction and their preferred measures for improving benefit sharing arrangements. Data was gathered from a total of 17 villages where REDD+ schemes were implemented. A total of 926 men and women were interviewed using an intra-household survey. Results show that women were more satisfied with non-cash benefits than men even though they were less likely to be included in the decision and design of benefit sharing. Men preferred cash benefits and were more likely to have participated in benefit sharing decisions. Across all countries the kind of benefits and their distribution was determined by implementing NGOs alone or in consultation with village authorities. Differences between men and women are linked to women's education, frequency of forest use and the migration status. The type, distribution and delivery of benefits need to align more closely with the preferences of resource managers. A mixed portfolio that includes cash and non-cash elements is preferable.

Gender, benefit sharing, REDD+

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118 - Nature-based tourism and recreation´s role in sustaining forests and improving people´s quality of life

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IUFRO17-3818 **Exploring small cities' influence on nature-based tourism and community development**

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Abstract: Nature-based tourism has several benefits, it provides jobs to local people and contributes to culture and natural resources preservation. Mexico attracts thousands of tourists every year due to its cultural and natural richness. Reports showed a 7.6% increase of international tourists from 2013 to 2015. However, its contribution to rural development is exiguous. There is an increase interest for nature-based, agro-tourism, and adventure types of tourism that opens the possibilities to explore strategies that suit tourists' demand and local people's desires to fulfil demand. This study described the profile and perceptions of visitors of San Ignacio de Arareco, a Mexican ejido in Sierra Tarahumara Chihuahua. The area of the ejido is 20000 hectares of pine-oak forest, and its population is of 2273 indigenous Tarahumara. It has seven natural attractions, a water fall, water springs, four geological formations, and the lake of Arareco. A sample of 284 tourists were interviewed in holly week 2015, the principal reasons to visit the area are cultural attraction and natural scenes. Although tourists spent 3000 US dollars per family in average, only 2 dollars is received by the community, Creel the closest town receives all the benefits of the cultural and natural attractions, due to its infrastructure to host tourists.

Rural development, indigenous community, tourism

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IUFRO17-2092 **Giving locals a say in promoting tourism by enhancing recreation in the wildland urban interface in Florida, USA**

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Abstract: Although nature-based tourism and recreation are often considered to exist under the same conceptual umbrella, researchers and practitioners often take widely different approaches to understanding and implementing the activities. However, regional planners often look to local nature-based recreation areas as potential attractions to lure tourists for potential economic benefits. Research will be discussed that examined how to best introduce tourism opportunities into parks and conservation lands through understanding the needs, desires, and concerns of local residents in Hillsborough County, Florida, USA. Research conducted a three-phase approach that included 1) nominal group meetings with key interest groups to the conservation areas, 2) a survey of community residents who participated in public meetings, and 3) a wider survey of county residents. Results show that although interest groups and stakeholders who attended public meetings had similar opinions on potential tourism opportunities, a broader sample of local residents hold diverse perspectives on appropriate tourism opportunities for local parks and conservation areas. Specifically, residents who lived adjacent to parks were significantly more likely to value physical fitness and solitude opportunities while residents who lived more than five miles away valued festivals and other social opportunities. Implications for management will be discussed.

nature-based tourism, recreation management

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IUFRO17-941 **Recreational hunting - a source of income for forest owners and a contested pastime: A survey of attitudes of the general public in Denmark**

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Abstract: Hunting as a recreational activity can be an important source of income for forest owners. But it stands apart from other forms of outdoor recreation in involving the pursuit and killing of wild animals. This study identifies the general Danish public's attitude to recreational hunting and explores attitudinal differences associated with six demographic characteristics, the conditions under which hunting is carried out, and respondents' so-called wildlife value orientations. It is based on a national survey from 2012 of the general public using an Internet-based questionnaire sent to a representative sample (n = 1,001). 43% of the general public had a positive attitude, 31% were indifferent, and 26% had a negative attitude to recreational hunting. Attitudes were associated with the way the hunting is organized, the type of lease, and some types of hunting. Respondents with a "mutualist" wildlife value orientation had the most negative attitude to hunting. A rethink of hunting as part of the leisure industry may be considered, since the least positive attitude to hunting was found in relation to commercial hunting. The results also raise questions about the compatibility of recreational hunting with other outdoor leisure activities. Tighter hunting regulation might have knock-on effects on forest management practices.

Wildlife values, hunting attitudes, Europe

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IUFRO17-1861 **From place-based natural resources to value-added experiences: Future nature-based tourism in the bio-economy**

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Abstract: Nature-based tourism is an increasingly important sector of the Nordic bio-economy, and the potential for further growth is high. This presentation will discuss key conditions for further development of this sector, thereby strengthening its contribution to business innovation, community development and sustainable use of natural resources. Contemporary nature-based tourism is undergoing significant changes in terms of diversification, globalization and new technology. Such changes call for an inter-disciplinary research approach to build cutting-edge knowledge on resource use, demand structures and product configurations. The point of departure for this presentation is the BIOTOUR project, a multi-disciplinary research project supported by the Norwegian Research Council with the overall hypothesis that an integrated perspective of the nature-based tourism sector will provide a basis for new products and more sustainable development. Through literature studies and structured communication techniques based on Delphi methodology, the project analyses key changes and trends with respect to nature-based tourism in the bio-economy. The presentation will provide an overview of the most prominent trends and analyze associated challenges for the nature-based tourism sector. BIOTOUR has a special focus on composite adventure experiences, genuine wildlife experiences, the role of trails and events in a nature-based tourism context.

Nature-based tourism, Bio-economy, Trends, Delphi

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IUFRO17-3009 **Touristic and recreational uses of forests in peri-urban areas: a case study in Veneto (Northern Italy)**

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Abstract: Forests and rural landscapes are crucial for tourism development and recreational activities and they may be relevant resources to invest for attracting visitors and contribute to the local economy. Tourism can also be an important development factor in terms of employment opportunities at the local level, thus contributing to the wellbeing of local communities. However, while mountain forests and landscapes are well-known and often properly managed for touristic/recreational uses since long time, small and fragmented forests in peri-urban, lowland areas are less valued.
The paper focuses on lowland forests in Veneto (Northern Italy) located close to Venice and other touristic places along the Adriatic Sea. The area is visited every summer by about 3 millions of tourists and, starting from 35 years ago, has been subject to a large afforestation program. Forests are owned by local Municipalities, while management activities are carried out through various forms: direct management by Municipalities, management agreement with private companies or not-for profit entities, rent to private, etc. Forest owners and managers are supported by the Lowland Forest Association (Associazione Forestale di Pianura, AFP), a unique case of private-public cooperation in lowland forest management in Italy. AFP has been established to help active forest management in the area, encourage positive impacts for locals and enhance the dialogue with multiple stakeholders.
Management operations are not just financed through Municipal budget, but also through funds raised by the AFP via other sources, such as the Rural Development Program and private investors. Ongoing and planned investments aim to increase the capacity of the forests to deliver ecosystem services, including cultural ones. The study provides economic data about the value of ecosystem services and a cost-benefit analysis of planned investments, also in connection to tourism and recreation activities.

lowland forests, tourism, recreation, AFP, Italy

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IUFRO17-2627 **Rural tourism: Its feasibilty frontier as seen from empirical evidence**

Paredes, M. D. R.* (1); Mendoza, M. A. (1)

(1) Colegio de Postgraduados , Veracruz, Mexico

Abstract: Tourism, and most other economic activities in rural communities in Mexico are perceived as fully or partially failed attempts. Only a few cases are presented as success stories. This research follows a theoretical welfare model to assess rural tourism performance. Simulated sensitivity runs were used to define the extent and general shape of the solution space. Main factors linked to rural tourism were identified as feasibility boundary restrictions for rural enterprises. A study case is presented to illustrate the trends and limitations of nature based tourism in the current Mexican scenario. Rural tourism in Mexico is feasible only marginally because of the combined effect of tourism and other land regulations. Still, when a place has valuable attractions, rural tourism is a positive addition to other productive endeavors. The study case, in Western Mexico, involves several forest land owners who collectively manage their properties. The tourism activity for them implies a net present value of USD $21 per hectare added to their fixed assets. Owners expressed interest in tourism as a complement to timber production and other products from the land. Their situation can be shown to represent region-wide trends.

Mexico,outdoors,finances,simulation

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IUFRO17-2677 **Low density nature based tourism, a study case from Mexico**

Paredes, M. D.* (1); Mendoza, M. A. (1)

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Abstract: The interplay between timber management, outdoor recreation, and nature-based tourism is examined. Eleven-year records from one forest in Western Mexico allow a characterization of the tourist's experience visiting timberlands under silvicultural management. The picture emerging from the study case is that visitors leave with a favorable opinion of a forest devoted to commodity production, but they will not experience environmental and culturally important scenes when these occur in less productive lands, and in late successional stages. The economics of this educational process is less attractive than alternate means. The total cost of one day visit in the study case is around USD $119; visitor direct expenditures reach up to $ 75 USD. The difference is managed as indirect timber costs, or it is written off from fixed assets such as land. Landowners feel that nature tourism is deterring further regulatory restrictions to forestry, a benefit, if any, accrued to all timber producers, regardless of how many forest owners have this dual timber and tourism business.

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IUFRO17-1653 **A Survey on Awareness and Demand of Urbanites about Introduction of Mountain Eco-tourism**

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Abstract: The public's attention to forest recreation and the demand on the tourism experiences in mountain villages have recently increased, which requires introducing mountain eco-tourism, by utilizing the existing accommodations and experience facilities established by Mountain Village Development Project and the surrounding ecological, recreational, cultural, and tourism resources. Therefore, the survey on urbanites' awareness and their demands was conducted in order to set the direction of mountain eco-tourism as a new policy project. This survey consists of the current situation, the demand, intention of participation, and the expected effects of mountain eco-tourism. From July 24th to August 15th 2015, an online-survey was conducted targeting 1,000 adult females and males over 18 residing in 16 urban and provincial areas. As a result of the major analysis, 75.4% of respondents answered that they visited mountain and rural villages for tourism and 88.1% intended to participate in mountain eco-tourism. They revealed their intended times of participating: 46.1% of them intended to visit once a year and 32.1% twice a year. On average, the respondents intended to pay USD138$(138,000KRW) for total travel expenses. Regarding the demand for mountain eco-tourism, 82.6% asked for improvement of accommodations and convenience facilities, 77.9% public relations and information offering, and 75.5% development of local tourism products. As for the expected effects of mountain eco-tourism that were perceived high, 80.4% expected natural healing and health care, 74.5% local revitalization, and 71.6% educational effects. This research is expected to be utilized as baseline data for mountain eco-tourism policy making reflecting urbanites' awareness and demand.

mountain eco-tourism, urbanites'demand, intention

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IUFRO17-1098 **Changes in the livelihoods of people in protected areas in China**

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Abstract: With the establishment of protected areas, mixed outcomes show up to local people. By denying their access rights to natural resources, a series of changes happened, including related resettlement (voluntary or involuntary) and intervention programs development, such as ecotourism development. This study focuses exploring when ecotourism development: 1) what changes are local people experiencing? and 2) which factors impact on people's livelihood strategies and outcomes? In order to deepen understanding about the impacts of ecotourism development and resettlement on local people's livelihoods in protected areas in China, sustainable livelihood theoretical framework was used. 100 semi-structured interviews with local people and management officers in Jiuzhaigou Biosphere Reserve and Shennongjia National Nature Reserve in China have been done. This study found that physical and financial capitals are crucial for local people to share the benefits from the ecotourism development.

livelihood; protected area; local; China

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IUFRO17-1059 **Recreational Indicators in the Danish National Forest Inventory - 10 Years of Experiences and Results**

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Abstract: Several international processes aim to monitor the forest status, and the political focus on the recreational/social function is increasing - as well as the demand for cost-effectiveness of the monitoring efforts. This paper describes, to our best knowledge, a unique forest recreation monitoring approach which is part of the compulsory Danish National Forest Inventory (NFI).

The NFI is based on a 2 x 2 km grid, with a cluster of four sample plots placed in each corner of a 200 x 200 m square in each grid cell. One fifth of the sample clusters are monitored each year. Before including recreational indicators on a permanent basis, a trial inventory was accomplished in 2006-2007. This trial identified 11 recreational indicators, including e.g. trails, hunting facilities and litter, which was meaningful seen from a recreational point of view and manageable in the existing inventory system. Results founded on a total of 4,138 forested clusters inventoried in 2008-2012 (which makes up the first full sample circuit) is presented.

It was e.g. found that hunting facilities were present on 27% of the clusters; forest roads/trails on 35%, while tracks were found on 17% - indicating access facilities are present at more than half of the Danish forest area. The presence of other outdoor recreation facilities, like campgrounds and fireplaces, were more limited (6%). An interesting observation is made in relation to conflict management: only at 1% of the clusters there are coincidence between hunting facilities and other recreational facilities. The results can be related to e.g. ownership status and geographical/administrative regions.

It is revealed that NFI's relatively simply and cost efficient can be expanded to include a number of recreational/social indicators which generally is not available otherwise. The continuity of the measurements will be a valuable addition to sustainable knowledge-based management and policy decisions.

Recreation, monitoring, national forest inventory

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IUFRO17-1856 **On-site data vs. population data vs. panel data - How to best monitor the society-forest relationship?**

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Abstract: Forests are important for tourism and recreation, especially in the Nordic region where they represent a large share of the land area. Previous research has shown that proximity to forests in urban regions significantly contribute to perceived well-being for many people. Likewise, protected forest areas contribute to increased recreation opportunities that could generate appreciative actions through nature interpretation programs. Forests also play a significant role for the consumption of tourism "space" in Nordic landscapes. To better understand and manage abovementioned values from forests it is critical to monitor visitor use in a systematic way. Visitor monitoring provides key information for not only management and planning of natural areas, but also for resource allocation, public accountability, enhancing visitor experiences, marketing and interpretation. There are, however, many different approaches to monitor visitors in nature areas, and this presentation discusses pros and cons of using on-site data vs. population data vs. panel data. The analysis is based on experiences from several studies of outdoor recreation and nature-based tourism in Sweden, and among topics discussed are applicability, reliability and feasibility of the different methods.

Visitor monitoring, Outdoor recreation, Surveys

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IUFRO17-1536 **Forest in Switzerland from the point of view of the Swiss public: Results of a nationwide monitoring survey**

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Abstract: There are several dimensions of the relationship between forest and the people, such as general forest preferences, the attitudes towards the ecological, protective and productive function, forest-recreation behaviour etc. The aim of a Swiss nation wide survey was to investigate these dimensions and to compare the results with those of a former study 1997.
To reach these aims we conducted a nationwide representative telephone and internet survey (N=3022, response rate = 32%) in the whole of Switzerland (all three language regions).
The results show that the provision of air and oxygen, the protection of traffic lines and settlements, the ecological function and the production of wood are among the most important forest functions from the point of view of the public. Nevertheless, forest recreation is very important for the Swiss people. They visit the forest in the average 1-2 times per week in summer and 1-2 times per month in winter. This means that Swiss forest-visit frequentation has one of the highest levels in Europe. However, forest-visit frequency did not increase since 1997 but very slightly decreased (statistically not significant). Nevertheless, the perceived conflicts in the context of forest recreation doubled since 1997. This might be the result of the increasing number of recreation activities that are conducted in the forests. But these conflicts did neither reduce the overall satisfaction with the forest visits nor the perceived restoration by them. They are both rated on a very high level. We also investigated the forest preferences and the respective assessment of the mostly visited forests and found that the people differentiate regarding concrete forest attributes such as the existence of dead wood, species distribution, infrastructure elements and so on. Mostly the preferences and perceived actual state matches well which explains the high satisfaction with forest visits in Switzerland.

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IUFRO17-549 **Integrating social and physical aspects of forest recreation - a new approach to a comprehensive monitoring**

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Abstract: Forest monitoring normally either focuses on physical aspects assessed in National Forest Inventories such as tree species, stand structure, etc. or on social aspects assessed in questionnaire surveys focusing on the relationship of people with the forest. However, especially regarding forest recreation, both the physical characteristics of the forest in which recreation takes place as well as the social aspects such as visitor preferences and behaviour play an important role. The question arises whether National Forest Inventories (NFIs) and socio-cultural forest monitoring (usually nationwide questionnaire surveys) could be combined to explain and possibly even predict forest recreation patterns from forest-related and visitor-related data. One possible approach to achieve this is to take (parts of) the questionnaire from the household survey and use them in a forest visitor survey at NFI sample plots. The second possible approach is to take visualizations, e.g. in form of photographs, of NFI plots with underlying forest data and use them in a survey. We tested both approaches with the aim of developing a model to predict visual attractiveness and recreational usage of the forest from physical and social data. An evaluation of of both approaches can provide indications to how a comprehensive forest recreation monitoring including both physical and social aspects could be conducted effectively.

Links physical and social data, method development

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IUFRO17-1701 **An analysis of communicative interaction as a tool to understand the dynamics of society-forest relationship in Baden-Württemberg**

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Abstract: In recent years political discourse faces challenges regarding transparency, citizen participation and the value of different forms of knowledge. Forestry does not remain unaffected by these dynamics: The public increasingly questions silvicultural management decisions and demands to have a right to be involved in decision-making processes. Therefore the branch has to seek higher transparency and to include the perspective of the public as a different form of knowledge into professional discourses e.g. by considering people's values and needs and therefore implementing participatory processes.

First results of a research project are presented focusing on the monitoring of these and further dynamics between and within forestry and the public. The sociocultural forest monitoring funded and conducted by the Forest Research Institute Baden-Wuerttemberg, Germany (FVA) has a local focus on forests in southwest Germany. The research design does not reproduce existing opinion surveys for another local area but it uses a qualitative method approach. Findings are based on the analysis of different instances of communication such as public relation events, civic engagement, and participatory processes.

Communication,Dynamics,Participation,Qual.Methods

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IUFRO17-3413 **Timber or Non-Timber Forest Products: How do stakeholders perceive the ecosystem services provided by tropical forests in Central Africa?**

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Abstract: Ecosystem services (ES) correspond to the benefits provided by ecosystems to humans. The integration of environmental, economic and social approaches in ES assessments is essential to strengthen policy decisions on land use planning. However, most ES valuations only use ecological and economic approaches. Social research methods are generally neglected, despite their fundamental relevance. Few studies assessed ES perceptions in developing countries, particularly in sub-Saharan Africa where the need for sustainable ecosystem management is vital. The aim of this study is to analyze the perceptions of the ES provided by southeastern Cameroonian forests to local populations. Perceptions of ES have been analyzed in three contrasted forest land uses: (i) three community forests, (ii) a protected area, and (iii) a FSC-certified logging concession. A total of 225 forest stakeholders were interviewed using a two-section questionnaire. Firstly, respondents were asked with an open question to describe interests and usefulness of their ecosystem. Secondly, eighteen ES classically attributed to tropical forests were listed, and respondents had to determine at which degree those services are provided or not, with a short justification. The ES bundled in provisioning, regulating and cultural services showed contrasted perceptions. Regulating services were perceived in the same way in the three land uses. Provisioning services were much important in community forests, followed by the logging concession and the protected area. In terms of cultural services, tourism activity was only reported in the protected area, and sacred places were mainly identified in the logging concession. As a conclusion, economic and ecological assessments of ES could significantly be strengthened and complemented with social approaches. Social techniques are clearly lacking in classical ES assessments, despite the need of an unequivocal understanding of stakeholders' demands and perceptions.

Ecosystem services; Perception; Land use; Cameroon

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IUFRO17-2313 **Quantification and regionalization of economic values of forest ecosystem services in Germany (ReWaLe)**

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Abstract: Societal demands of forest ecosystem services are growing worldwide. ReWaLe aims at the quantification and regionalization of economic values of forest ecosystem services in Germany. This is achieved by means of valuations of societal benefits of productive, protective, and recreational functions of forests in monetary terms, taking into account their inter-dependencies. The required data base results from new population surveys as well as from previous studies. A related meta-data base providing access to studies on forest ecosystem services was already made available to the public via the website of the institute. A GIS-based approach permits the management and geo-statistical analysis of geo-referenced data and facilitates the interpretation of the results. The outcome of the analyses constitutes the basis for a modeling approach. The resulting model will be applied for estimating the potentials for optimizing the benefits gained from different forest functions as part of sustainable and multifunctional forest management. The results are intended to support German forest politics in exhausting the optimization potentials of forest ecosystem services while simultaneously balancing commercial forestry against social and ecological aspects.

ecosystemservices, mapping, economic valuation, DE

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IUFRO17-1020 **Knowing past and learning for future: assessing processes of monitoring nature-based recreation and tourism**

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Abstract: Monitoring is a basis for foresight. In Finland, systematic nation wide monitoring for nature-based recreation and tourism started almost 20 years ago. The first assessment of monitoring, statistics and data basis took place in a project assigned by the Finnish government in 2016-2017. The goal was to provide suggestions to strengthen the information basis, and to develop a model for systematically updated foresight information for planning and decision making. This presentation aims to describe the array of data gathering, the method to assess current statistics and data basis, some of recommendations, and the model to provide foresight reports to government. The amount and variety of data gathering, and the output as statistics, indicators and data basis is large, covering recreation demand statistics and data basis for recreation services, in whole country and separately on state-owned lands, statistics of hunting and fishing, statistics of recreational homes and use of them, and statistics of enterprises and business of nature tourism. Most of the data gathering is long-term, funded by different ministries, but very few have their mission mentioned in legislation. Based on the systematic assessments, one of recommendations focus on the need to demarcate nature-based tourism from general tourism in order to get better understanding of it's the economic importance as one of the businesses of bioeconomy.

recreation, nature tourism, monitoring, foresight

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IUFRO17-1637 **The Swiss landscape monitoring program - bridging the gap between bio-physical space and perceived place**

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Abstract: Many landscape monitorings are limited to the physical and biological space, despite the fact that land-use is strongly linked to the socio-cultural realm via people's perception. The latter is an important component for quality of life and people's place attachment. The Swiss Landscape Monitoring Program LABES (abbreviation for German "Landschaftsbeobachtung Schweiz") is one of the first large-scale landscape observatories (total area ca. 40'000 km2) where landscape perception is systematically monitored with representative surveys. The entire monitoring consists of roughly 30 indicators that are embedded in the DPSIR framework (i.e. Driving force - Pressure - State - Impact and Response). Approximately 25% of the indicators measure perception properties. Respondents are instructed to base their statements on the landscape and places of their current home municipality rather than on pictures of specific landscapes. We distinguish two perception concepts: (1) an evolutionary determined perception component (concepts of Kaplan & Kaplan) and (2) a culturally determined component based on concepts such as e.g. fascination, landscape beauty or authenticity. Innovative indicators of the physical space are light emissions which is a straight-forward surrogate for urbanization and human activities. We also measure fragmentation and urban permeation as well as areas without buildings and infrastructure and close-by recreation areas. At the moment ca. 50% of the indicators are available as time series. A rigid quality control with advanced statistical methods showed that the indicators are geographically representative for Switzerland. A core set of indispensable indicators was determined and links between the physical and the perceived space elaborated.

monitoring, landscape, space, place, perception

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IUFRO17-2691 **Visitor Preferences for South Korea's National Park Management Alternatives: A Case Study on Seoraksan National Park**

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Abstract: An ecosystem can be valued and perceived differently by different groups of people, making decisions on the National Park (NP) management and conservation a difficult process. The perceived role and value of protected areas is to not only to help protect the natural ecological system, but also provide opportunities for recreation. Effective and sustainable management of protected areas relies on a complete understanding of public attitudes and demands.
The construction plan for a second cable car system in Seoraksan NP in Korea has resulted in clashes between different stakeholders. This research will explore visitor preferences among the potentially conflicting management priorities of Seoraksan NP. A set of hypothetical park profiles composed of select attributes of the park was presented to respondents in a Choice Experiments survey, and they were asked to choose their most preferred management alternative.
Based on the results of the online expert survey, biodiversity, special protection zones, nature observation trails, crowding and entrance fee were selected as park attributes. From the on-site visitor survey in October 2016, 146 valid responses (1,752 choices in total) collected and analyzed using the binary logistic regression method. Korean visitors were not affected by the level of crowding in the park as compared to other attributes. They considered the state of biodiversity in the park to be the most important attribute. The marginal willingness to pay for an increase in park biodiversity (from the current level to a 10% increase in endangered species' populations) was found to be 3,642KRW. A reduction in biodiversity was the most harmful feature regarding visitors' welfare. The welfare estimates revealed that in the best case scenario, the value per visit is 7,486KRW. From the park management point of view, increasing biodiversity, expanding special protection zones, and improving nature observation trails are valuable scenarios for park development.

national park, management, biodiversity, tourism

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IUFRO17-4144 **Brazil Park and Protected Area Management: Tapajós National Forest Case Study**

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Abstract: This Brazil case study demonstrates the critical importance of measuring visitor use in parks and protected areas. In December 2015, Brazilian national news outlets broadcasted segments featuring the Tapajós National Forest, located in the Amazon region. Within the Forest there is a large number of traditional communities. One of these communities, Jamaraqua, was the primary focus for many of these news segments. As a result of these broadcasts, visitation to the community of Jamaraqua increased overnight. Visitors soon discovered the natural features surrounding the community, particularly the "igarapés" or creeks leading to the Tapajós River. Specifically, this presentation shows that local park resource management decisions (ICMBio) were sound and effective. A critical management problem was identified and a solution was quickly implemented. The solution was successful in diverting recreationists (tourists and locals) from an environmentally sensitive, unmanaged recreation area to an established recreation area. The fast moving social media of 2015/6 resulted in an immediate impact on a specific area. The use of proactive management by local ICMBio resource managers, combined with a systematic visitor monitoring effort, resulted in a change in the social setting. This management change was implemented with the intent of reducing negative impacts in an environmentally sensitive setting within a protected area. Previous research suggests that making such preemptive management actions helps to build community and therefore has the likelihood of building capacity within the community. Continued systematic monitoring should continue within the area, and ICMBio staff can react as necessary to assist management if this issue should occur in other areas.

parks and protected areas, monitoring, experience

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IUFRO17-3887 **Developing Nature-Based Tourism in Finland - Implications to Research**

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Abstract: Nature-based tourism is a growing and increasingly recognized sector in the Nordic countries. Its potential has been also identified in the Finnish bio-economy, forestry and tourism strategies. This presentation discusses key measures and research needs for further developing this sector and the linkages between nature-based tourism and sustainable use of forest resources. The growth of nature-based tourism poses action needs for various agents working in this field, and it challenges also forestry sector to amend current forest management practices aiming still largely at timber production.

This presentation is based on findings of a national Well-being from Forest - research program conducted at the Finnish Forest Research Institute (2008-2014). The program produced research knowledge about social and economic benefits of forest-based recreation and tourism, studied development needs of the business sector and entrepreneurship as well analyzed synergies and conflicts between nature-based tourism and other type of forest uses. The presentations also discusses key results of an ongoing multidisciplinary project called "New ways to develop and enhance nature-based tourism and recreation in Finland" (2016-2017) commissioned by Prime Minister's Office with the overall goals to implement the current research knowledge within the governmental decision-making and also to identify the key future policy amendments and development goals together with key stakeholders in Finland.

Nature-based tourism, Bioeconomy, Forest planning

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IUFRO17-4172 **Spatial analysis linking recreation supply and demand data with health and environmental justice in Alabama**

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Abstract: Obesity rates continue to grow in all population groups in the United States. However, ethnic minorities and those from a lower socioeconomic status are affected disproportionately. Obesity results from a combination of numerous factors, and previous literature has highlighted the role of the built environments. Limited access to safe and affordable places for physical activity can easily translate to a sedentary lifestyle of those living in a disadvantageous environment. There are 14 Alabama counties with adult obesity rates of greater than 40%. A survey was developed to identify outdoor recreation preferences, demands, and barriers. Surveys were mailed to 500 citizens in each of the 14 counties with questions asking about participants' spatial access to outdoor recreation locations, barriers, current activity levels, as well as needs assessment for facilities. A total of 1,448 responses were received and analyzed using spatial analysis techniques in a geographic information system. Specifically, kriging was utilized to interpolate survey responses in order to create a maps of recreation use and opportunity setting need and in consideration with localized obesity rates and environmental justice considerations. Using this method, poverty, ethnicity, obesity and outdoor recreation needs can be presented in location specific terms practical for direct intervention.

health, recreation, physical activity

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IUFRO17-3419 **Local ecological knowledge (LEK) of forest practitioners and its relevance for biodiversity conservation - a literature review**

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(1) Wildlife Ecology and Management, Freiburg, Germany

Abstract: The ecological knowledge, individual practices and perceptions of forest practitioners play an important role for biodiversity conservation in managed forests.
To better understand this interrelation, a systematic literature review focusing on local ecological knowledge (LEK) is conducted. The analysis addresses the questions (1) which knowledge is considered in the studies, (2) how LEK holders are identified, (3) how their LEK is applied in everyday forest work and (4) how LEK is related to biodiversity conservation.
The review includes studies from several disciplines using different LEK terms all referring to a similar basic idea. Thereby, it strikes that many studies lack information on the methods used and on how LEK holders are identified. Most research centers on indigenous communities, whereas research on LEK of communities in the Global North is still scant, focusing on seldom ecosystems while rarely covering managed forests. Compared to studies about indigenous knowledge, it emphasizes site-specific, dynamic and pragmatic knowledge characteristics and neglects cultural and spiritual aspects. Although many studies stress the importance of LEK for biodiversity conservation, their interrelation or the functioning of knowledge systems are rarely analyzed in-depth.
Since LEK may usefully complement scientific knowledge, these issues should be further investigated to enhance biodiversity conservation.

Local ecological knowledge, biodiversity

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IUFRO17-649 **Influences of Culture on Management of Forests in Africa**

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Abstract: In most rural parts of Africa, cultural demands are more influential than scientific conclusions. The variety of cultural values ascribed to forests are as numerous and different as the communities and cultures. The success of community based forests management approach, which most governments embrace, partly depends on the cultural values of a community. A study was conducted in three selected districts of Malawi to understand how cultural factors affect communities' relationships with, use and management of forests. Empirical analyses of household surveys, key informant interviews and focus group discussions revealed that cultural uses of forests define the extent of forest cover, species diversity and utilization of forest resources. Lifecycle events such as births, initiation ceremonies, celebrations and deaths favor the conservation of specific tree species. Traditional leaders, not extension agents, are the most influential people in protecting forests through enforcement of cultural bylaws. For instance, community members are more likely to defy written laws of a village forest area than the unwritten laws regarding graveyard forests. However, some cultures require that family members bury their loved ones behind their houses hence no need for communal graveyard forests. While medicinal values are among the important uses of forests, only traditional healers are concerned with preserving the relevant trees. The use of leaves, bark and roots for medicine leads to dying out of trees. Burning bricks has become a cultural activity in most societies but also one of the main drivers of deforestation in Malawi. Forest management initiatives that are in line with cultural beliefs are more likely to succeed than those that work against them, but not all cultural practices are beneficial. This provides an opportunity for forest scientists and policy makers to leverage culture for policy formulation and sustainable management practices.

Forests, Sustainable Management, Culture,

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IUFRO17-1647 **Ensuring an integrated approach to the design of new eradication technologies - linking technical, social and cultural perspectives**

Allen, W.* (1); Ogilvie, S. (2); Brockerhoff, E. (3); Grant, A. (3); Kerr, J. (3); Langer, E.R. . (. (3); Mark-Shadbolt, M. (4); Marzano, M. (5); Pawson, S. (3); Richardson, B. (3); Strand, T. (3); Waipara, N. (6)

(1) Learning for Sustainability, Christchurch 8244, New Zealand; (2) Eco Research Associates Limited, Christchurch, New Zealand; (3) Scion, Christchurch, New Zealand; (4) Lincoln University, Lincoln, New Zealand; (5) Forest Research, Midlothian, United Kingdom; (6) Auckland Council, Auckland, New Zealand

Abstract: Successful integrated research relies on the effective participation and involvement of different disciplines and stakeholder groups. This can be challenging to achieve in practice because many initiatives fail to address the need for meaningful engagement and social learning within the research team - particularly when this requires linking across social, cultural and technical divides. We used an action research approach to support members of an interdisciplinary research group to critically reﬂect on their engagement practice and identify lessons around how to collaborate more effectively. Maori (the indigenous people of New Zealand) are significant as Treaty partners and stakeholders, and hence the research team has placed a focus in this area. The approach followed is based around the use of rubrics as a descriptive tool to reflect on best practices for working collaboratively in integrated programmes. This reflection on practice is set in the context of an integrated biosecurity research case. The design of new eradication technologies and their accompanying implementation protocols requires linking technical, social and cultural considerations. Rubrics that list the criteria required in inter- and trans-disciplinary collaborations are outlined, along with examples of effective engagement processes that directly support integration through such efforts. The work illustrates how multi-, inter- and trans-disciplinary approaches can provide a framework for considering the different conversations that need to occur in an integrated research program. Finally, the implications of these experiences for other researchers and managers seeking to improve engagement and collaboration in integrated science, management and policy initiatives are discussed.

interdisciplinary transdisciplinary action researc

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IUFRO17-3977 **Integrating forest conservation management practices with recreationists' perception of quality**

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Abstract: Many wildlife species (e.g., red-cockaded woodpecker [RCW]) require frequent prescribed burning in forests of the southeastern U.S., which might be aesthetically less appealing for many recreation visitors. This study examines recreationists' knowledge of prescribed burning and compares their perception of scenic beauty and recreation qality for forests that have undergone different stages of prescribed burning.
Pictures representing different stages of prescribed burning were taken from RCW habitat in the Ocala National Forests. Different recreationists (i.e., hunters, hikers, campers, OHV users, and canoers/kayakers) were interviewed to measure their knowledge and perception of scenic beauty and recreation satisfaction. The respondents were divided into two groups. A treatment group received an information that the pictures were taken from RCW habitat and this bird requires frequent prescribed burning. The control group did not receive this information.
Results showed that recreationists differ in terms of their knowledge about prescribed burning and its importance in wildlife habitat management. Respondents in the treatment group rated the pictures higher for both scenic beauty and recreation satisfaction than respondents in the control group. Likewise, comparison among the recreationists showed that hunters followed by OHV riders rated scenic beauty and recreation satisfaction higher than the other users.
Results suggest that information related to the purpose and ecological importance of prescribed burning would improve visitors' recreation experience and satisfaction when visiting sites with prescribed burns. Likewise, providing hunting and OHV riding would offer higher visitor satisfaction than by providing other opportunities on wildlife habitat requiring frequent prescribed burning.

Wildlife management, scenic beauty, satisfaction

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140 - Forest education - the consequences of interaction: innovation and curricula

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IUFRO17-1958 **Higher education in ergonomics - added value of innovative education of forestry students**

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Abstract: Ergonomics, a scientific discipline concerned with the systems of human-work interactions, plays an important role in the higher education of forest engineers. For the recent several dozen years an innovative nature of this discipline has been mainly expressed by the development of corrective ergonomics, resulting in continuous improvement of inappropriate and malfunctioning solutions, frequently harmful to humans engaged in various work processes. This concerns, e.g. ergonomic modifications in the construction of petrol chainsaws, ground drills, plant sprayers, thus most of the manually operated, mechanical devices employed by forest operators. A practical outcome of those improvements was a significant limitation of occupational hazards and a decrease in arduousness of work experienced by operators. However, the greatest innovation, in terms of its nature, is conceptual ergonomics, which for many years has been the driving power that stimulated and shaped an intense technical progress in forestry. These were ergonomists who designed and built modern machines, and developed technological solutions for innovative performance of forest works. An outcome of those ventures was not only the minimization of work arduousness and occupational hazards, but also a considerable improvement in safety and comfort of work experienced by operators. Among those one can name, e.g. harvesters and forwarders, cable yarding systems, field lines for wood chipping, or prototypes of self-operating machines, performing their tasks in forested areas without any assistance of operators. This close connection of the research development and its ergonomic applications with the progress in forest techniques and development of technologies of forest works, should be given its due attention in education of foresters, bringing as a result new innovative added values into forestry and higher education of foresters.

education, ergonomics, innovative, forestry

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IUFRO17-4159 **Outcome-oriented curriculum design**

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Abstract: Most forestry curricula emerged over time, and there have been many voices calling for a systematic re-design, based on learning outcomes (skills and attitudes) rather than contents. Whereas systems engineering developed a set of approaches and methods to design complicated systems, curriculum design is still an activity that is driven by common sense and by the interests of academic instructors.
The presentation aims to (1) review the requirements engineering philosophy to develop a consistent set of curriculum outcomes, (2) sketch such a requirements framework for a basic forestry education program. This approach requires a paradigm change from "content-driven" to "outcome-driven" curriculum design, which decreases the importance of traditional forestry disciplines, embodied in university professorships. A successful implementation requires an organizational development process to move faculties to a new ground, upon which new curricula will be developed.

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IUFRO17-1283 **Non-formal environmental education in Poland - goals, methods and curricula**

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Abstract: The subject of this research is to check the work of environmental education centres and educators teaching environmental education. The research involves not only a comprehensive analysis of the organizations providing nature and forest education but it also explores broadly defined education including its goals, methods, and curricula to review the education quality assessment.

This work accommodates a tool for testing the quality of environmental education developed by the Swiss Foundation for Environmental Education(SUB) and SILVIVA Foundation consisting of two checklists and a manual. This tool allows for a detailed self-assessment of the organization and the course of its environmental education. Additionally, it provides qualitative analysis by devising corrective actions in those areas where intervention is needed.

The survey has been carried out in Poland. The entities selected for analysis are divided into several categories, namely: National Forests, Urban Forests, National Parks and nature and forest education centers associated with other organizations or research institutes.

The aim of this work is to address differences and similarities across different types of organizations in terms of purpose, method and content of nature and forest teaching (environmental education). It further seeks to show whether and in what areas the organizations and institutions providing environmental education see the need to improve the quality of education, whether these areas are substantially different across the organizations falling into the above-mentioned categories, which indicators were considered important for surveyed organizations, and whether the need to apply corrective action was observed and proposed. The results of the survey will help portray environmental education as provided by different entities.

The research will be repeated in subsequent years and its results compared.

forest education, environmental education, Poland

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IUFRO17-3643 **Introduction of the novel master programme "Urban Arboriculture and Forest Management"**

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Abstract: Urbanisation is one of the major social and environmental changes occurring in the 21st century. By 2020 almost 80% of EU citizens will be living in cities. At the same time there is a growing awareness that cities are dependent on ecosystems inside as well as outside the city's limits and that increasing integration of greens and forests into urban areas offers greater environmental benefits. Urban trees and forests also address citizens' natural desires and add to aesthetic or spiritual values that increasingly collide with common management operations like silvicultural treatments, harvesting or felling of roadside trees.
Thus managers of urban green and forests do not only need specific arboricultural and silvicultural knowledge but also the capacity to mitigate competing or even conflicting interests centered around the management of urban greens and forests.
The University of Applied Sciences and Arts Hildesheim/Holzminden/Goettingen (HAWK) takes these latest environmental and social developments into account by creating a novel and innovative master programme named "Urban Arboriculture and Forest Management". The course addresses graduates of arboriculture and forestry alike and offers specific science-oriented courses broadened by courses on the development of interdisciplinary and transdisciplinary competences as well as social skills that are indispensable for the developing and managing of a multifunctional green infrastructure in complex urban settings and in future developments.

urban forests, conflicts

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IUFRO17-2546 **Observer effects during habitat tree selection**

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Abstract: In managed forests, retention of habitat trees is one of the main measures taken to promote biodiversity. The retained trees are to provide ecological niches (microhabitats) on which an important share of forest-related species depend for their survival. Typically, only a few habitat trees per hectare are selected and it is hence of primary concern that trees with the most desired characteristics are preserved.

In the present study we investigated human tree selection decisions with regard to habitat tree selection based on an quasi-experimental approach. Experiments took place within a so called marteloscope, basically a tree marking training site, for which an inventory not only of economic values of the single trees but also of their microhabitats is available. Results show that observers consistently selected habitat trees with a low economic value. However the ecological value of selected trees varied considerably. In addition, selection behavior depended on observers' social background and profession. In another part of the experiment marteloscope exercises with forestry students were used to learn more about the habitat tree selection process. To do so, a unique experimental design was developed in order to combine research and educational objectives. Pre and post observations enabled us to detect that the most important learning effect was linked to the amount of microhabitat types per tree and the total tree's habitat value rather than to the amount of microhabitats per tree. Conclusive, it seems that habitat tree selection can still be improved and marteloscopes seem to provide a very promising environment to do so.

microhabitats, student-centered, marteloscope

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IUFRO17-3522 **The Innovation of Educational Activities at the Faculty of Forestry and Wood Sciences Prague**

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Abstract: The aim of the contribution is to introduce a new educational strategy at the Faculty of Forestry and Wood Sciences Czech University of Life Sciences Prague based on the development of teaching facilities together with new educational methods and study programme innovation. The former includes new modern classrooms as well as teaching laboratories equipped with the most modern technology both in forestry and wood sciences as well as enhancing educational competences of the academic staff. The implementation of this strategy will require constructing a new high-tech pavilion enabling the students to acquire experience and skills, for example virtual reality in 3D caves, 3D modelling, remote sensing (drones), GIS, transmission and scanning electron microscopy, fire-proof properties of materials, construction on the base of wood and in a number of advanced technologies. The latter is based on the innovation of study programmes in line with the needs and requirements both of forestry and wood industry and according to the requirements of the new Universities Act that was adopted in the Czech Republic in 2016.

Forest education in Prague, innovation strategy

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IUFRO17-2288 **The Forest Culture Centre in Goluchów as an important link between the forest education and Polish society**

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Abstract: The need for the popularisation of forestry and the knowledge about the forest in Poland was stressed in the end of 19th century. Decades of efforts by Polish Forest Society led to the creation of the Museum of Forestry that preserves the heritage of Polish forestry and promotes its role in the society by showing a multitude connections between forest and humans. In 1983 the institution was opened together with holding a first public exhibition. The following exhibitions held by the Forest Culture Centre, which incorporated the historical park-arboretum as well as the corral of animals - these became places for environmental education.
The Centre operates within the structure of the State Forests. It is the oldest and the most experienced institution providing extracurricular forest education. This is also the place where its forms have been developed and improved for almost 30 years. There are passive and active forms of forest education, for example, guided tours, temporary exhibitions, publications, field and museum lessons, artistic workshops, competitions, ecological initiatives, festivals, conferences. Some of them are done in cooperation with other natural history museums, educational institutions, associations and units of the State Forests.
Polish and international tourists, pupils and teachers working across different levels of education, educators, scientists and academic, cultural and museum institutions benefit from the educational activity of the Centre. Every year 35 thousand of people visits the museum and nearly 100 thousand comes to see the corral of animals and almost 12 thousand takes advantage of active forms of forest education.
The Centre publishes methodology and general science books, guides and teaching aids and also does publications for children and young adults. The Forest Culture Centre also carries out research to investigate the extent of forest education at a local and national level as well as within the Centre itself.

extracurricular education, Museum of Forestry

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IUFRO17-4174 **Developing a Competency-Based Climate Education Program for U.S. County Extension Agents**

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Abstract: County agents in the United States need the necessary tools to communicate the complexities and issues related to changing weather and climate patterns. Farmers, ranchers and forest owners have questions related to the impact of weather and climate on their production and ecosystems. To address this gap in knowledge and capacity, the Office of the Southern Regional Extension Forester contracted with the USDA Office of the Chief Economist to develop the nationally based Climate Learning Network (climatelearning.net). The goal of this online network is to develop a national climate literate extension professional through online education, training, mentoring and networking. A series of competency-based meetings were held to determine competencies needed by today's county extension educator. These competencies were then incorporated into existing and planning for current and future online learning modules.

The learning modules were developed from webinars and other resources and are housed on the Climate Learning Network's website. Experts from around the country were invited to prepare and present webinars on a number of key topics ranging from introductory lessons to more involved lessons concerning adaptation and mitigation of agriculture and silviculture systems. The CLN is currently in it's 3 year of operation and seeks to provide an opportunity for all county agents in the Country to improve their understanding and ability to answer climate and weather-based questions from their constituents. More importantly, the CLN seeks to empower agents to develop active programs in the area of climate and weather science.

Climate change, extension, forest management

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IUFRO17-2175 **Mathematics and Statistics - Their Role in Modern Forest Curricula**

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(1) HAWK Hildesheim/Holzminden/Göttingen, Fakultät Ressourcenmanagement, Göttingen, Germany

Abstract: On the one hand in our modern world even everyday-activities are based on mathematics, on the other hand the interest of most of the people - including students of forest science - in this subject is still pretty low.

On the one hand complexity of research methods and research results increases and their interpretation becomes more and more demanding, on the other hand a multitude of aspects of natural and social sciences are crucial for understanding forest science and forestry comprehensively nowadays. So we walk into the dilemma that courses are time consuming and curricula are limited.

For all that reasons applied mathematics and statistics have to be incorporated in a modern forest curriculum just as slim as intelligent as goal-oriented, supposing that there is no doubt about the absolute necessity teaching it.

Mathematics is always present, whether we will notice it or not. This includes all levels of forest education.

But dependent on the general competences and the knowledge, at which the educational efforts aimed at, goals, learning-targets, areas of knowledge and teaching strategies in the field of applied mathematics and statistics will be different.

Criteria for a consistent placement in diverse curricula will be given as well as meaningful learning targets and adequate teaching strategies.

mathematics, statistics, curriculum, teaching

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IUFRO17-3478 **Developing a novel Master on Sustainable Forest Resource Economics: Chances and Challenges**

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(1) HNEE, Professor for Forest Utilization and Timber Markets, Eberswalde, Germany; (2) HNEE, Professor for Forest Resource Economics, Eberswalde, Germany; (3) HNEE, Professor for GIS and Remote Sensing, Eberswalde, Germany; (4) HNEE, Professor for Forest Growth and Yield, Eberswalde, Germany

Abstract: Emerging policy and business trends for bioeconomy, together with a wide range of societal interests for forest ecosystem uses demand for revised curricula for forest management. A M.Sc. "Sustainable Forest Resource Economics" is therefore developed at Eberswalde University for Sustainable Development that seeks to educate critical forest managers that can actively guide such developments. The Master program takes an ecological-economic perspective on the assessment, valuation and use of forest resources as part of larger transformation strategies. As its central focus, bundles of forest ecosystem services and their multiple benefits are analyzed, and options for their provision are elaborated and assessed. The program focuses on three core thematic areas:

First, novel approaches for forest resource management are discussed that include the demands of stakeholders affected. Accompanying, forest resource economics is introduced as a way of thinking in- and experimenting with, governance alternatives such as new incentive-based policies or private sector payments for internalizing the values of forest ecosystem services.

The second focus is on policy instruments and governance strategies. Guiding is the understanding that searching for tradeoffs and balancing societal interests cannot be coordinated by markets only but are part of larger governance strategies. Governance systems and (re) configurations of market approaches, state regulations and actor networks are examined, and methods for analysis and assessment introduced.

An innovation system-based understanding forms the third focus to guide the transformation of forest management and the development of new business and policy models.

The program is strongly interdisciplinary in nature, seeking for a constructive exchange that crosses sectoral and disciplinary boundaries. It provides multiple possibilities for graduates to find employment in companies as well as e.g. in administration or business and policy consulting.

Resource Economics, Bioeconomy, Ecosystem Services

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6 - Open Session

KG I - 1015 (Uni Freiburg)

IUFRO17-3217 **Unity and Variation. The logic of qualitative inquiry in forestry research.**

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Abstract: Qualitative methods in forestry research are established to a certain extent. However, results of qualitative studies are frequently questioned in terms of their generalizability - often enough by qualitative researchers' own modest claims. While many qualitative studies in forestry research are indeed "only explorative" or illustrative, others aim explicitly beyond such limitations. A number of qualitative methodologies define reasonable standards for generalizability, all of which lie within the qualitative paradigm, irrespective of sample size. The paper explores these qualitative standards. It does so by comparing the logic of inquiry implied in different methods such as narrative interviewing, episodic interviewing, group discussions, and participant observation. The overview presented in the paper is not exhaustive but rather contrast-driven. It serves to identify general unifying principles across methodological differences as well as important variations in the logic of data production and analysis. It further asks what kinds of knowledge claims the respective methods make, whether and how they accomplish a particular kind of generalizability, and also what their epistemological limitations are. Throughout, the argument is supported by examples from forestry research.

qualitative methods, epistemology, methodology

KG I - 1015 (Uni Freiburg)

IUFRO17-1524 **Qualitative interviewing: a self-reflection on two decades of personal experience**

Brukas, V.* (1)

(1) SLU, Southern Swedish Forest Research Centre, Alnarp, Sweden

Abstract: For almost two decades, the author of this abstract went through an exciting and enriching journey of qualitative forest research. Starting with humble steps of simply collecting some qualitative comments along quantitative survey question for "better understanding" (e.g. Brukas et al. 2001), I increasingly realized the great power of qualitative information, leading to studies where results are narrated "with the lips of respondents" (Brukas et al. 2016) or to meta-narratives that synthesize the insights from more than a hundred of qualitative interviews (Brukas 2015). In the proposed presentation, I will reflect on this qualitative journey touching upon such aspects as (i) epistemological and ontological reasons for the personal transition from the quantitative to the qualitative; (ii) examples of discoveries thanks to deep and open interviewing; and (iii) the ultimate impact of qualitative research: do our words matter more than the colleagues' numbers?

qualitative interviews, epistemology, ontology

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IUFRO17-4090 **Qualitative Research between wish and reality: the challenge of managing "imperfect" data**

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(1) Black Forest National Park, Seebach, Germany

Abstract: In an ideal world, the researcher can work with qualitative data collected in a perfect and elaborated way. In the real world, this is often not the case, due to limited resources as lack of time or money. This paper elaborates on the challenges of analyzing data collected in such an "imperfect" manner, based on one section of the qualitative data collected as part of the socio-cultural monitoring of the German Black Forest National Park. This socio-cultural monitoring aims at understanding the relationship between society and nature. Considering the complexity of social meaning, it takes an innovative and comprehensive approach including representative surveys, narrative interviews, discourse analysis, participant observation as well as experimental methods. The data used in this paper consists of 50 qualitative guided interviews, conducted by trained persons under the framework of the socio-cultural monitoring. Topics included recreation in the forest and perceptions of nature and wilderness. However, these interviews took place on the telephone and were strictly limited in time. Based on the present case, the challenges of varying data quality are discussed. There are certain limitations, but it is argued that, given a thorough analysis, data collected in an imperfect way can be a valuable contribution to gain insights into people's relationship to forests.

Handling qualitative data quality

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IUFRO17-2853 **Materially engaging with the forest - Doing research on body practices in forestry**

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Abstract: Materially engaging with the natural world is one common aspect linking the different realms of interdisciplinary biodiversity research in forestry to the world of forestry practitioners and practices. In order to understand the role of tacit knowledge connected to practices of physical field work of both researchers and forestry practitioners (such as climbing trees to search for epiphytes or evaluating the value of a tree), qualitative researchers need to engage bodily with their worlds of study. I focus on the epistemological implications of the practice of participant observation as a method of co-presence of bodies interacting with and in the material surrounding of the field, for example the forest or the laboratory. Related to that is the question of how to record, interpret and communicate about data on body practices and material interactions. What would it mean, for example, to use the body as both the object and the instrument of research, as it has been suggested? I draw on recent theoretical and methodological debates related to the fields of sociology of knowledge, new phenomenology, science & technology studies and new materialism in order to reflect on methodological aspects of both human and non-human materiality in research on knowledge production in forestry.

materiality body practices participant observation

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IUFRO17-2868 **Reaching out to diverse and excluded groups**

O'Brien, L.* (1)

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Abstract: Much of the research on ecosystem service provision and the benefits people gain from engaging with forests is captured through primarily quantitative methods. Qualitative research in this area is also undertaken; however commissioners of research raise issues about the small scale of the research, its representativeness, and whether the findings can be scaled up. This presentation will discuss research focused on excluded groups including those with autism, drug and alcohol problems, and emotional and behavioural difficulties. A study is being undertaken for the Forestry Commission at its national arboretum in England. The aim is to evaluate how a community inclusion intervention is impacting the wellbeing of participants. Mobile methods were used of spending the day with specific groups, working with them and carrying out interviews with staff, volunteers, group leaders and participants (where possible), and undertaking participant observation. Results suggest that if only one of these methods had been used the experiences of the groups would not have been adequately captured. The study is part of a larger study that includes a survey of visitors to the arboretum. The mixed methods approach allows multiple sources of data gathering. However, it is critical to recognise when it is appropriate to use what type of method. To do this an understanding of the study participants is crucial, as well as working with research commissioners to understand evaluation needs. Case studies of specific groups or individuals and quotes of people's experiences can be powerful. Synthesising qualitative, and sometimes including quantitative, data from across a range of studies can be a useful way to scale up findings and illustrate commonalities and differences across different groups of people. This evaluation shows the importance of repeated visits for participants to become at ease and familiar with the site.

excluded, mobile methods, cultural benefits

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IUFRO17-2364 **Going deeper with documents: exploring new applications for extant texts in forestry research**

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Abstract: The use of documents in forestry research has tended to play a supplementary and supporting role relative to other forms of social data collection (e.g. interviews and participant observations). Here we explore the use of extant texts (unsolicited documents) in a more central role. We argue that in-depth, critical analysis of documents can reveal important insights for understanding whose ideas, interests and values underwrite forest practices and decisions in communities and how power is exercised. We first discuss how documents are currently viewed and used in forestry research and contrast this with work that sees texts as socially situated, worth attracting the analytic scrutiny of the researcher (Charmaz, 2006); particularly in relation to other documents (Atkinson & Coffey, 2010). Following a typology developed by Prior (2008), we then distinguish between using documents as "topic" and as "resource" in research on forest communities to discuss how records like forest management plans can be analyzed to explore their use and function in community settings. We conclude by discussing novel approaches to communicating the outcomes of document analysis (e.g. through timelines).

qualitative research, documents, visualization

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200 - Gender, climate policy and the future of the forests

KG I - 1224 (Uni Freiburg)

IUFRO17-284 **Gender norms and gendered impacts of oil palm conversion in Indonesia: Challenging private sector commitments to climate change mitigation**

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Abstract: The 'zero deforestation' movement has received ready applause across a wide spectrum of actors for bringing together private sector corporations to commit to climate change mitigation. This is particularly the case in Indonesia where lowland tropical forests continue to be converted to make way for oil palm production and state-lead measures have apparently failed in reducing and halting deforestation. Although women in oil palm-dominated landscapes play integral roles as oil palm producers and workers alongside their responsibility for household food security, critical questions about gender equality have thus far been absent from the zero deforestation policy agenda. We will present on findings from three case studies of gender dynamics in oil palm frontier landscapes in East and West Kalimantan, Indonesia, where rapid expansion of smallholder oil palm investment by returning cross-border migrants and other groups sits alongside an expanding corporate sector. The case studies serve to illustrate the role of gender norms in enabling particular kinds of oil palm investment on the one hand, and in shaping pathways to inclusion, exclusion and dispossession on the other. Amongst smallholders, we found a less emphatic masculinization of resource access and control, and some instances of women¹s empowerment in an emerging smallholder oil palm market. In comparison, changes in corporate business models in response to the Indonesian Government ¹s laissez faire approach towards smallholders tied to plantations, on the one hand, and the rise of distinct forms of collusion and rent-seeking between corporations and local authorities, on the other, have been particularly detrimental for local women on these frontiers. We argue that zero deforestation pledges may inadvertently reinforce gendered impacts of oil palm expansion, with serious consequences for gender equality and women's wellbeing.

Gender, zero deforestation, Indonesia, oil palm

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IUFRO17-2496 **Gender Perspectives in Local Nature Protection Initiatives: Experiences from Sweden**

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Abstract: The quests for broadening initiatives for nature protection stem from policies at both international and national levels, according to which local governments should strengthen and promote implementation of the UN Convention on Biological Diversity. In Sweden, starting in 2004, the government has allocated special funding towards this end, to be matched by local funding. In total, 261 of the 290 municipalities have been allotted such funding towards local projects. The projects should build upon broad local engagement in order to facilitate widened access to nature and promote recreational activities, including the improvement of nature areas, pathways and nature information, aiming to inspire new societal groups to enjoy these areas. This paper discusses the possibilities and problems in making such local nature areas accessible to new citizens and immigrants, disabled and of all ages, in particular children through schools. Examples are drawn from pioneering projects across Sweden. Institutional constraints and strategies are examined in view of how gender perspectives might be better fostered in future policy making for nature protection.

engagement, nature protection, gender perspectives

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IUFRO17-694 **Gender, climate and forest governance in Canada**

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Abstract: Research on climate change in the global north has been dominated by natural scientists; correspondingly, investigation of mitigation and adaptation options has focused on technical solutions and physical infrastructure. This bias may be unintentional, but its effect is that social dimensions of climate change have been under-represented in climate change discourse and decision-making institutions. In institutions of forest governance in Canada, particularly within forest-based communities, climate change is just emerging for discussion and action. Where such work has been initiated, the greatest focus has been placed on better engineering, planning for robust infrastructure, and 'reinforcing' the community's physical geography to withstand sudden shocks such as fire, flood, or pests. Yet, many of the effects of climate change at the community level test the social infrastructure, such as provision of social and community services, emergency support systems, and long-term reconstruction of social networks. Yet, the social infrastructure - typically gendered female - is rarely considered within the limited planning efforts underway. This paper explores these issues by drawing on results of a 2016 national survey of forest-based advisory committees composed of residents of forest-based communities. The survey asked committee members how they understood climate change issues in forestry and what actions their committees had taken to plan for climate change. By undertaking a gender-based analysis, I explain how community risks and responses to climate change have been framed and consider alternative needs for planning and response to encompass social dimensions.

gender, climate change, forest governance, Canada

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200 - Gender, climate policy and the future of the forests

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IUFRO17-754 **New types of private forest owners: Understanding female forest owner behaviour towards Climate Change Adaptation**

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Abstract: The presentation will focus on the human dimensions of climate change and adaptation of small-scale private forest owners in Austria. In Austria approximately 95 000 forest owners manage roughly 56% of the Austrian forest area with individual properties smaller than 5 ha. Due to changing family structures and traditions the amount of female forest owners is increasing. This presentation will look explicitly at the decision making of female respondents under conditions of climate change. The findings are based on a survey including forest owner's perception of climate change, motivation for forest ownership, and the planned behaviour under conditions of climate change by using a choice experiment (CE). Overall a total of 919 forest owners participated in the questionnaire whereas 20% were female. The contact information was provided from six different sources and contained respondents from all over Austria. The female forest owners were analysed towards their duration of forest ownership, their motivation, preferred forest tending and maintenance in contrast to the male forest owners. Furthermore we analysed the likelihood of female participants to apply climate change adaptation strategies in their forests. The findings reveal significant differences and show that tailored approaches are required for contacting this group of forest owners. New campaigns, targeting topics such as alternative soft forest management, soft procedures, or challenges of climate change and adaptation for management need to be developed. The results underline that funding - even if it would be increased significantly - will not be a useful tool to steer the overall development. Hence, relevant authorities need to investigate new door openers which are able to engage explicitly female small-scale private forest owners.

female forest owners, CC adaptation, choice model

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IUFRO17-582 **Depoliticized or creating room for political debate? Addressing gender in REDD+ co-benefits and safeguards**

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Abstract: It has frequently been argued that climate change is the epitome of depoliticisation (MacGregor, 2014; Stephan, et al 2014; Swyngedouw, 2013). In programs such as the Reduced Emissions from Deforestation and Forest Degradation (REDD+) this is manifest in the focus on managerial approaches to measuring, reporting and verification (MRV) and the safeguards adopted to counter critique and fears of adverse effects on local communities and biodiversity from REDD+ interventions (den Besten, et al 2014; McDermott, Coad, Helfgott, & Schroeder, 2012). Critics however fear that safeguards risk being relegated to technical issues unable to redress power relations that determine climate outcomes and social justice concerns on the ground (MacGregor, 2014). Despite rhetoric, few efforts have been made by implementing institutions to clarify how to address gender in REDD+ (Bee & Sijapati Basnett, 2016). For example, McAfee (2016) argues that the conceptualisation of REDD+ as a win-win solution has turned it into a matter of maximizing benefits, while questions of justice and responsibility are buried under discussions of technicalities of management.
This paper aims to analyse the relevance of examining REDD+ as a case of depoliticisation. It asks whether safeguards and co-benefits - two key concepts in REDD+ - serve merely to close off debates and silence critique, or whether in their operationalisation at national and local level there might be opportunities for reopening political debate about how to do REDD+. The depoliticisation thesis is examined specifically in relation to the potential for bringing a transformative gender analysis into REDD+ programs. Analysing efforts made by women's NGOs such as WOCAN and WEDO at integrating gender in REDD+ safeguards, we discuss strategies for promoting a gender transformative agenda in climate programs at the local level. This discussion draws on feminist literature to inquire into the opportunities for 're-politicising' gender in REDD+.

gender depoliticisation REDD+ climate policy

All Division 6 (Social Aspects of Forests and Forestry) Meeting

19 - The role of forests in sustainable rural development in developing countries: livelihoods and quality of

KG I - 1015 (Uni Freiburg)

IUFRO17-2894 **Changes in the ecosystem services obtainable in native forests: economic evaluation**

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Abstract: Ecosystems in general, and natural forests particularly, can generate different output values (e.g., food production, environmental regulation and socio-cultural worth), as well as insurance values. The latter is the value of ensuring that no regime changes occur with irreversible negative consequences for human wellbeing. Even if an ecosystem or its components currently do not generate any output value, insurance value can be significant.
The aim of this study is to estimate the value of the various services and benefits that ecosystems and biodiversity generate and analyze the different assessment approaches. The results of the assessment will depend largely on the social, cultural and economic aspects, whose boundaries may not overlap with the definition of the relevant ecological system. For better evaluation it is essential that there is adequate coordination between all stakeholders.
Despite the difficulties of transferring the valuation approaches and results between world regions, the transfer of benefits can be a practical, quick and inexpensive way to get an estimate of the value of local ecosystems. Values will vary with the characteristics of the ecosystem and the beneficiaries of the services it provides.
The monetary valuation can provide useful information on the welfare changes that will result from the actions of ecosystem management, but the valuation techniques have limitations, especially important as ecosystems approach critical thresholds and ecosystem change is irreversible or reversible only at a prohibitive cost. Under conditions of high or radical uncertainty and existence of ecological thresholds, the policy should be guided by the principles of "minimum insurance" and "precautionary approach".

Natural forests; Ecosystem services; Valuation

KG I - 1015 (Uni Freiburg)

IUFRO17-806 **Examining the role of markets in non-timber forest products and the implications for climate change adaptation in Uganda**

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Abstract: How markets affect adaptation remains unclear. This paper examines the roles of markets in non-timber forest products that normally serve as safety nets for forest communities, and the implications for climate change adaptation in Uganda. Following the identification and prioritization of forest-based development sectors for adaptation by stakeholders, the types of markets and trades surrounding the identified sectors were examined in two regions in Uganda as a case study in order to evaluate revenue flows and their potential contribution to adaptation by local communities. The distribution of the market revenue leaves local people with returns much lower than the worth of the commodity, while wholesalers and retailers reap most of the benefits and profit from the high variability in volume and market earnings for the same commodity across regions. Markets may increase the value of a commodity, but their contributions to adaptation appear highly limited for local communities following their distribution among the stakeholders in the market chain. This is likely to be worse in free market settings, especially when it diminishes the safety net roles of forest goods and services. Markets should therefore complement rather than substitute forests roles for adaptation to climate change in tropical forest countries.

Markets, Non-timber forest products, Adaptation

KG I - 1015 (Uni Freiburg)

IUFRO17-3880 **Land use planning tools for forest and rural development in Delta del Paraná**

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Abstract: In Argentina, the expansion of the agricultural frontier affects the conservation of natural resources, and in the Paran á Delta could compromise the production of ecosystem goods and services and sustainability. This, among other aspects, reveals an insufficient territorial planning and, in some cases, determines the inadequate use of land.

We have been able to test different planning tools based on the needs of different representatives of the forestry sector. In the particular case of the Delta, its main concern was the navigability of the waterways through which goods and people are transported.

A participatory model of multi-criteria analysis (MoPAMC) was used that included ecosystemic, productive, social and economic aspects. Public participation strategies were implemented that promoted the sensitization of social stakeholders related to forest production. In this way, an attempt was made to increase the social valuation of regional ecosystem services and regional forest production.

In the construction of the MoPAMC, a set of representatives of different groups of territorial stakeholders defined the assessment of the proposed planning criteria. The selected criteria and their respective weights (with 100 as the maximum value and 0 as a minimum) were as follows: Schools (91); Areas with the highest population density (89); Public transport - collective and school buildings (87); Health Centers (82); Productive Areas (78); Forest Consumption Centers - Sawmills and Harbors- (75); Recovery Areas with Productive Potential (64).
From this model a proposal was generated to be financed by the Ministry of Agriculture, Livestock and Fisheries of the Nation which included the improvement in 270 km of waterways.

The implementation of the participatory workshops was fundamental to identify strategic problems and to know the stakeholders assessment of the different ecosystem services, in this case, the navigability of waterways.

Land use; Delta del Paraná; multi-criteria

All Division 6 (Social Aspects of Forests and Forestry) Meeting

19 - The role of forests in sustainable rural development in developing countries: livelihoods and quality of

KG I - 1015 (Uni Freiburg)

IUFRO17-3723 **Supporting sustainable development and responsible forest management by giving forest communities new tools to access benefits from ecosystem services and ecosystem service markets**

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Abstract: In this paper we introduce the benefit models through which positive impacts for forest communities could materialize from the use of new certification tools for ecosystem services.

Traditionally forests have been seen as sources of goods and their management has focused on timber production. The rise of the concept of ecosystem services has meant changes in the way forests are seen but so far the implications to their management have been limited. Despite limited markets for ecosystem services provision so far, certification standards have foreseen a potential market niche and have moved into certification of ecosystem services. Forest Stewardship Council (FSC) has been developing new tools dedicated to ecosystem services to deliver additional monetary and non-monetary benefits for certificate holders and communities. The approach has been tested in a pilot project (ForCES - forces.fsc.org) in Nepal, Vietnam, Indonesia, and Chile. The core of the approach is using a verified demonstration of positive impacts to gain improved access to payments for ecosystem services, as well as improved benefits for the preservation of ecosystem services and relationships between stakeholders.

Key questions that we address are: 1) what are the enabling and limiting conditions for FSC ecosystem services benefit models to have a positive impact on rural development; 2) what is the scale of opportunity and 3) What are the most effective vehicles for delivering benefits? We show practical examples from both monetary and non-monetary benefits that contribute to sustainable development in rural areas and potentially long-lasting positive livelihood outcomes.

Ecosystem services, benefits, certification

KG I - 1015 (Uni Freiburg)

IUFRO17-1676 **The impact of forest plantations on the household's access to natural forests and farmland in East Africa**

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Abstract: This study explores the impact of large-scale plantations and associated industrial operations on adjacent communities. Renewed interest from investors, governments and enterprises in planted forestry has been meet with doubts from communities, and NGOs. This paper examines the impacts of sustainable forestry operations compared to conventionally managed government-owned operations on access of households to forest products and land availability. We present the results of a literature review and structured interviews with 505 workers and 664 households in four communities in Tanzania and Mozambique; two focus group discussions in each community; and soil, water and biodiversity measurements conducted between January to May 2016. We examine access to forest products (timber and non-timber products), perceived and measured impacts on natural forests and biodiversity, and access to land and small-scale woodlots. We compare the impacts of privately-owned plantations to state-owned plantations. A mixed analysis method using multinomial logistic regression to quantitatively investigate relations between plantations and access and incomes and qualitative analysis to investigate perceptions, causality and attribution, and triangulate data. The results aim to inform about the sustainability of large-scale forest operations and agroforestry in developing countries, and provide evidence about mitigating negative and enhancing positive impacts of changes from customarily governed common-land to concession managed planted forests.

Plantation, Tanzania, Mozambique, certification

KG I - 1015 (Uni Freiburg)

IUFRO17-1989 **The role of natural forests in the sustainable development of rural communities**

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Abstract: The aim of our work is to promote discussion by analyzing the principal function of natural forests in the sustainable development of rural communities into developing countries. This issue is multifaceted because it involves different aspects, social, political and environmental, being indispensable that there is adequate coordination between all administrations and organizations involved. During the last decades it has been accentuated the decline in area covered by natural forests. Both the human population will grow at a rate that will require different resources, livelihoods, perhaps two or three times higher. A livelihood includes people and their capabilities, including food, income, and other resources. It is considered sustainable when at least keeps the assets on which it depends and can also provide them for future generations. Multi-functionality of native forests, multifunctional use, promotes the establishment of markets for local forest products other than wood which could generate capital for sustainable management linked to rural development. Policy makers, private ownership of forests and the individual's ability to identify the opportunities are key factors in creating growth opportunities for rural communities. Comments from the authorities indicate the need for training programs to present the opportunities offered by forestry.

Native forests; Forest management; Local progress

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KG I - 1015 (Uni Freiburg)

IUFRO17-116 **A multidimensional participatory strategic model for promoting the sustainable community forestry and human wellbeing in México**

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Abstract: In Mexico, there are challenges for achieving sustainable community forestry development. Globalization, climate change and biodiversity loss have created the need for building capacities in forest ejidos (common property land) and rural communities. The main objective was to promote the application of a participatory forestry management model (different to traditional processes) in forest ejidos for sustainable development. The model included a Multisearch Conference methodology, which is a participatory and bottom-up decision-making process, and a participatory strategic management model of the competitiveness of community forest enterprises. The model is based on strategic thinking, holistic vision and participatory democracy, and includes strategies for designing, implementing and monitoring strategic plans for sustainable forestry development. The application of the model allowed to the local people better motivation and appropriation levels of participatory decision making processes for driving their own development. Examples of outputs of this model are a participatory strategic master plan for sustainable forestry development in Chihuahua, Mexico, and integral forestry project of the forest Ejido "El Largo and Anexos", Madera, Chihuahua, Mexico. In sum, the participatory forestry model promoted anticipatory and self-managed sustainable community forestry development. The model represents a paradigm shift in order to get sustainable community forestry development.

community forestry development,forestry Chihuahua

KG I - 1015 (Uni Freiburg)

IUFRO17-3537 **Typology of Smallholder Industrial Tree Plantations (ITP) in Caraga region, Philippines**

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Abstract: Caraga region once prided itself as the timber corridor of Southern Philippines. Five decades ago, many municipalities in Caraga grew from the spin off economic activities spurred by the wood industries in the region. Economic boom did not last long when the government cancelled timber license agreements since 1980's. Hence, this study conducted a review of secondary data and household survey of tree farmers to generate a profile and distribution of these farmers and relate them to the prevailing conditions of the area.

About 61.35% of the Private Tree Plantation Ownership Certificate (PTPOC)holders who registered from 2005-2012, had an area of less than 5 hectares. Thus, majority of the households engaged in tree farming are considered as smallholders which pertains to household level tree plantation development, including backyard planting, covering an area of less than 5 hectares.The average household size in the region is five. About 94% of the entire household population in Agusan del Sur are engaged in forestry, especially on smallholder tree farm development for Falcata, Gmelina, rubber and others.This indicates that income from tree farming has become an important source of growth in the province.

smallholder, tree farming, ITP

KG I - 1015 (Uni Freiburg)

IUFRO17-2938 **Collecting Styrax benzoin tap and conflicts of land tenure in customary forest in North Sumatra, Indonesia**

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Abstract: Collecting Styrax benzoin tree tap in customary forest is a sustainable way of life inherited for generations in North Sumatra. Customary forest have had traditionally individual land holdings, in which collecting the tree tap is a significant means of livelihood. The government partially entitled a pulp company to the concession to cut the trees and plant first growing trees as Eucalyptus, which evoked conflicts between local people and the company. This study investigates; 1) how local people may collect the tap, 2) how much money they can earn from the activity, 3) how conflicts evoked between the two parties.

Household survey and interviews with local people and NGOs revealed that local people had approximately 1 ha of customary forest and collected the tree tap mainly twice a year, which is their daily subsistence and main income source. While customary forest traditionally owned by them have been partially deprived by the government with the juridical land classification, the forest environment changed badly, induced the reduction of the amount of the production and jeopardized the traditional property right of local people.

NTFP, customary forest, conflict, Indonesia

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19 - The role of forests in sustainable rural development in developing countries: livelihoods and quality of

KG I - 1015 (Uni Freiburg)

IUFRO17-2516 **The complex balance between nature conservation and livelihood of local residents in a State Park**

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Abstract: This research analyses the livelihood of local residents in a state park situated at Atlantic Forest (Brazil). When the park was created human groups habited the region and a conflictive situation emerged. For the Afro-descendants communities their rights to the land was recognized but others like the community Ribeirão dos Camargo still claim ownership of the land on which they live. The main economic activities of the inhabitants were slash-and-burn agriculture, hunting, fishing, raising pigs and chicken. They also made use of the forest as a source of firewood, medicine and food, material for crafts and construction and repair of houses. With the establishment of the Park the main activities of local residents were criminalized, with consequences on the reproduction of their livelihood. Many residents have left due to restrictions on agricultural use of soil and extractivism. If the current scenario does not change the disappearance of community' family farmer is inevitable. They will move from family farmer, craftsman and pigs farmer to night guard, driver, cook, and servant. With family farmer' disappearance will be lost a local agro-biodiversity and an accumulation of knowledge of the relationship man-nature that could be valuable to improve biodiversity conservation in this State Park.

Park; Livelihood; Conservation; Conflict

KG I - 1015 (Uni Freiburg)

IUFRO17-778 **Endogenous knowledges, use and folk perception on conservation status of orchids in Sudanian zone of Bénin**

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Abstract: In Benin, people have always had traditionally rich ethnobotanical knowledge on plant species reflecting cultural and ecological diversity of their environment. This study examined (i) use and differences in knowledge of orchids and (2) conservation status of orchids based on folk perception. Four tribal groups were interviewed in Sudanian zone of Benin. Data were gathered from semi-structured interviews and analysed using quantitative ethnobotanical methods. Overall, 34 different use forms were mentioned for 12 orchid species grouped into four main use categories: medicinal, food, veterinary and social. Fifty eight percent of orchid species were really used with a significant difference among the tribal groups, gender and age. Calyptrochilum christianum is the most used (21.88% of surveyed), mentioned in more than 50% of orchid use forms. Gourma tribes had the largest knowledge in orchid use. Medicinal use category was correlated best with the Gourma tribe with only old women having knowledge in use of Habenaria cirrhata for swollen feet. H. cirrhata was also the only orchid used as food. Based on folk perception, conservation gap can be assumed to most of rare epiphytic orchids in gallery forests. From our results, it is crucial that traditional tribal knowledge of orchids be preserved.

Orchid, folk knowledges, use value, Sudanian zone

All Division 6 (Social Aspects of Forests and Forestry) Meeting

30 - Managing recreation: Empirical insights and forest management instruments.

KG I - Aula (Uni Freiburg)

IUFRO17-1282 **Modeling forest recreation in Baden-Württemberg, Germany**

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Abstract: Forests in Germany are of great importance for the leisure and health of the population. Accordingly, the Forest Law stipulates that "forest functions must be recorded by forest function mapping and must be pursued as necessary." In recent decades, both the recreation in forest and landscape and the societal demands on the forest have changed quantitatively and qualitatively very much. To be able to model these changes on a regularly base in the future, the FVA started to develop its field of research activity "Forest Recreation" in 2008. On the base of a triangulation of qualitative and quantitative social research methodologies and GIS tools, a network-based model has been generated to map the spatial distribution of forest visitors. The data consist of 2 telephone surveys (respectively n=2000) and 25 qualitative interviews. All data were collected in Baden-Wuerttemberg. With the newly developed modeling method by the FVA, the existing data on the use of the forests will be updated for recreation. For instance, references for the spatial extension can be deviated from this. The model incorporates service areas around settlements, parking spaces and forest entries as well as places of attraction and points of interest. The underlying parameters are directly retrieved from representative inquiries about people's recreational activities and preferences throughout the state.

forest recreation, modelling forest functions

KG I - Aula (Uni Freiburg)

IUFRO17-2459 **Impacts of bark-beetle infested forests on recreation**

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Abstract: Extensive outbreaks of introduced and native forest insects are globally increasing and can result in both tourism revenue and timber value losses. Little research exists on visitor response to visual changes in forest recreation settings. Few, if any, studies have examined how forest visitors weigh trade-offs between social factors such as visitor numbers and physical factors of bark beetle-impacted forests and how these vary nationally or internationally. This study examines these trade-offs in Germany, Austria and the USA.
This study used a stated preference approach. A discrete choice experiment employed digitally-calibrated images to simulate forest stands with varying levels of bark beetle outbreaks, different management practices in response to the infestation, and varying visitor uses. On-site surveys with more than 750 visitors were conducted in 2014.
Results revealed the condition of the immediate forest surrounding was the most important attribute for visitors' landscape choices. Visitors preferred vital, mature and mixed forest stands, and disliked scenarios with substantial dead wood. The number of visitors was the most important social factor for visitors' choices. Differences between study sites were observed. This study shows that forest insects have a negative impact on cultural ecosystem services, in this case, on landscape preferences and recreation.

cultural ecosystem services; landscape preferences

KG I - Aula (Uni Freiburg)

IUFRO17-2105 **Impacts and Challenges of the Development of Recreational Sports in Forests in Japan**

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Abstract: Recently, the recreational use of forests by sports users, such as mountain bikers, trail runners, survival gamers, has remarkably increased in Japan. This study explored the impacts and challenges of the development of recreational sports in forests by conducting interviews of the sports users, users' associations, and forest owners and managers whose forests were targeted by the sports users.
The results showed that the sports users engaged in conflicts with forest owners and managers who were concerned about forest degradation and bearing liability for accidents, and with walkers who felt threatened by the sports users. The conflicts with stakeholders got more strained because the Japanese authorities has not enacted clear rights, rules, and responsibilities for accessing and using forests by the sports users.
Furthermore, the interviews confirmed that some leaders of the sports users were now building their associations, which could represent them to resolve the conflicts with stakeholders through consensus building with local communities and forest owners. Some of them were even organizing the sports users' activities to maintain trails and to participate in local forest management. These organized efforts were gradually welcomed by the local communities and governments bothered by the declining population, and became a key to the development of rural mountain areas.

Mountain Biking, Trail Running, Survival Games

All Division 6 (Social Aspects of Forests and Forestry) Meeting

30 - Managing recreation: Empirical insights and forest management instruments.

KG I - Aula (Uni Freiburg)

IUFRO17-142 **Governance of forest recreation: the challenge of managing and planning forest recreation in urban forest areas.**

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Abstract: Forest in Switzerland are multifunctional. Forest recreation is regarded as one of these multi-functionalities. Forest recreation is given because forests for recreation are defined under federal law (article 699 of the civil code) as being an open-access common-pool resource. Subsequently, anyone can visit forests by foot at any time without regarding ownership (public and private). However, this definition of forests for recreation possess challenges to forest managers and policy makers. The challenges forest managers and policy-makers are facing and to which we refer are liability issues, costs issues, conflicts issues. Subsequently and in order to improve the planning and management of urban forest areas the governance of forest recreation has to be analysed. This is done by using the Institutional Analysis and Development (IAD) framework, developed by Ostrom (1990) to investigate open-access and common-pool resources. Through the application of the IAD framework we expect to identify all relevant action situations in forest recreation planning and management, to identify the stakeholders needed to be involved in each actions situations, to identify the institutions which frame the process and subsequently to describe the outcomes which result from the stakeholders interactions. To do so, case studies were selected based on the criteria biophysical world (intensity of recreational use of forests among others), community attributes (ownership) and rules-in-use (Cantonal Forest Development Plan). The research draws on several empirical sources including forest inventory data, national statistics, semi-structured interviews (May, 2001) and peer-reviewed papers.
The findings suggest that the governance of forest recreation is very heterogeneous and strongly constrained by local circumstances. Therefore having insights from other parts of Europe or beyond facing similar challenges as the ones presented is strongly recommended.

Forest recreation, Forest Conflicts, IAD Framework

KG I - Aula (Uni Freiburg)

IUFRO17-2218 **Balancing landscape-level forest management between recreation and wood production**

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Abstract: Many forested landscapes are used for both wood production and outdoor recreation. Intensive forest management has often a negative impact on the forests' recreational values. This is also the case in Sweden, a country with rich forest resources, and a strong forest industry. Urbanization has led to the majority of people living in urban areas, thus increasing the importance of and demand for urban and peri-urban recreational green areas, such as forests. It is the responsibility of the local government - the municipalities - to provide a good living environment for their inhabitants, including recreational areas. However, most of the forest area in Sweden is owned by private individuals and companies, which have a large degree of freedom in their forest management decisions. Municipalities have the possibility to make formal agreements with forest owners for protecting forests with high recreational values, but this requires financial resources which often are scarce. Thus, tools are needed for identifying forest areas that should be prioritized, that is, forests where adapted forest management should be considered to maintain or increase their recreational value. In this study, we test a model that identifies forests with a high suitability for outdoor recreation for a case study area in southern Sweden. The model is included in a forest decision support system, and links locational aspects, such as population density and nearness to water, with forest structure aspects, which is simulated over time under different management strategies. Our results suggest that an increase in the recreational value of a forest landscape can be achieved with relatively small losses in average net present value, for example by extending rotation periods. The model could be useful for more efficient planning of the recreational potential of forests at landscape level.

forest planning, recreation index, social value

KG I - Aula (Uni Freiburg)

IUFRO17-2259 **Informal trails in forested areas close to Zurich. Consequences?**

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Abstract: Recreational use of forest areas can cause some degree of environmental damage. This can include the formation of visitor-created informal trails. Nowadays, proliferation of such trails is an important management concern in many natural areas worldwide. The study investigates informal trails within three peri-urban forested areas close to Zurich, Switzerland.
Data was collected in early summer 2015. Informal trail segments were characterized by numerous parameters and mapped using a GPS device. Within the three study areas (23.8 km2) a total of 19.7 km of informal trails was detected. 77 % of those trails were used by hikers and 71 % were used by mountain bikers.
Research findings showed significant higher values in average slope, side-effect of trail width and max. trail incision for informal trail segments used exclusively by mountain bikers. Results highlight how informal trail use can result in cumulative damage such as degradation of land cover and soil or exposing roots depending on the type and intensity of the recreational activity. Although impact of trails is mostly limited to a linear disturbance corridor, informal trails increase in severity in fragmenting sensitive areas and habitats. Informal trail-based fragmentation is responsible for the creation of 146 patches in the total study area, which is an increase of more than 20 %. Additional experiments with roe deer have shown severe reactions to activities disturbance with off-trail activities.
An appropriate trail-network should have a channeling effect. The occurrence of informal trails can indicate a lack of adequate official trails. Results provide a scientific basis for management decisions to minimize the impacts caused by informal trails. Management should seek to limit the formation of informal trails and should close ones, which pose a threat to the ecosystem.

informal trails, trail technical features, mountai

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40 - Engaging equality: The construction of gender and forest through processes of gender mainstreaming

K 5-7 (Konzerthaus Freiburg)

IUFRO17-551 **The gender bias in forest ownership succession**

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Abstract: Female forest ownership in Sweden has been increasing only very slowly during the last 20 years and is at present 38%. In a society with a marked focus on gender equality, one can wonder why this share is not increasing faster. The most common way to become a forest owner even today is by taking over the property from the parents. In modern western society, children have much stronger right to decide upon their own future than their parents have had. For the ownership succession plans, this means that children nowadays have more influence in the decision to succeed. A study among adult children to forest owners in northern Sweden revealed that women were 3 times less willing to succeed their parents as forest owners than men. Yet when the children's experience in helping their parents was added into the logistic regression model, gender was no longer a significant factor. Women that denied their willingness to take over the property also expressed to a larger extent than men, that their parents did not need their help. The study shows that there is still a gender bias in the succession process. Parents seem still to adhere to the traditional cultural script in socializing their sons into the concept of forest ownership rather than their daughters. Introducing children to nature activities has shown to affect their future participation in such activities, therefore it seems crucial for the succession process that parents include their children in activities related to the property already at an early stage in the child's life.

succession, intergenerational transfer, children

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1698 **Gender aspects in Lithuanian private forest ownership**

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Abstract: The aim of the paper is to analyse the gender aspects in Lithuanian private forest ownership. Private forest holding management strategy and objectives, its dependence on gender and women's role in family forest ownership are important issues which should be analysed and discussed. The analysis is based on data of private forest owners' database and qualitative expert survey, which have been carried out in 2016.
The number of women in private forests ownership increased very rapidly in Lithuania during last decades. The main reason of this was restitution process of private forests to former owners, which started in 1991. The survey, which have been carried out in 2005, results showed the gender influence on objectives of forest holding management, decision-making manner, forest-related activities etc.
Despite the fact, that many forest holdings are inherited or bought by women, the forest management is remaining the "men-dominated" activity as traditionally. Often women give the dominant position to men because men are stronger physically and often have better forest management practical skills. The legislation provisions (harvesting permits, sales contracts, EU support) promote the family members (wife and husband) to be equally interested and responsible in their forest management, so more and more women become active in private forests management.

gender, private forestry, forest management

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2138 **Different but equal - Polish women in forestry education situation**

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Abstract: In Poland women and men are offered equal conditions for education, employment, professional careers and salaries. The guarantee of that is national law. Real situation differs from legislative image. Research indicates that both the wage gap, problems with career development, the proportion of employment and the frequency corresponding to the management does not agree with proportions of women choosing forestry education and profession. Gender aspects have been increasingly recognized as an integral part of sustainable development, and therefore of Sustainable Forest Management (SFM). SFM is based on the management and use of forests and forest areas in a manner and at a rate that is ensuring also the preservation of their social potential in a long run. The objective of this women oriented research was to analyse and evaluate education in forestry labour equality from gender perspective. Structured phone interviews, document analysis and forestry schools internet web pages content, were used to supply detailed data. Shortage of women on university stages of education is evident as well as limitations of the development of a scientific career. Thus, the proportion of women among the teaching staff in higher forestry education institutions declines with every step on the academic career ladder. Existing "'glass ceiling" for women may also be a result of the dominant masculine culture that is present generally in academia. There is a need to emphasize the existence of this phenomenon and propose ways to fix it.

Women, equality, forestry, education

All Division 6 (Social Aspects of Forests and Forestry) Meeting

40 - Engaging equality: The construction of gender and forest through processes of gender mainstreaming

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2759 **Women in Forestry Association - a good practice in gender mainstreaming example**

Pigan, I.* (1); Nowacka, W. L. (2); Armatys, L. (3); Niebrzydowska, B. (4)

(1) The State Forests Bielsko Forest District, Bielsko-Biala, Poland; (2) The Warsaw University of Life Science, The Faculty of Forestry, Warszawa, Poland; (3) The State Forests Chrzanow Forest District, Chrzanow, Poland; (4) The State Frests KatowiceForest District, Katwice, Poland

Abstract: Forestry is perceived as a typical masculine profession, globally as well as in Poland. 75% of the State Forests National Forestry Holding, main employer in Polish forestry are men. The disparity is even higher on the management level.
The whole range of contemporary management theories and researches show, that gender - both male and female - predominance is correlated with numerous negative trends concerning mostly women. This paper shows The Women in Forest Association activity, representing good practice trend, yet they are induced by employees and remains bottom-up.
The Woman in Forest Asociation main goals are integration and supporting women working in forestry, discovering and promoting female leaders, women rights protection. The targets are to be achieved mainly through numerous conferences, workshops and trainings organized exclusively for women as well as initiating and supporting researches concerning gender in forestry. The latest project is to establish a cooperation with organizations in Europe.
So far events organized by Women in Forest Asociation gathered more than 1000 women. During 8 years of our activity we organized 7 national conferences, 3 regional ones, differently themed workshops. This year an internet survey concerning our activity and women situation in the State Forests National Forestry Holding was done. It will be presented along with permanent monitoring of the gender balance in the State Forests.

Woman in Forestry Association; gender equality

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1973 **Tropical forest work: certification requirements and gendered data**

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Abstract: With the revision of the FSC Principle and Criteria for Forest Stewardship the certification organization is introducing from 2017 on for forest operations in any country of the world to "promote gender equality in employment practices, training opportunities, awarding of contracts, processes of engagement and management activities." These requirements go far beyond the earlier references in FSC standards to related ILO core conventions. In the paper we point out how national FSC standards for different tropical countries address this criterion in indicators, combining international concepts for gender equality with national realities in responsible forest management and specifically for forest work; we will explain what kind of evidence forest managers have to bring for compliance with the criterion; and whether or not auditors identify strength or weaknesses of certified forest management operations in responding to these indicators, on the basis of the analysis of certification reports. One of the effects that this criterion brings is the need for reporting on gendered data, which are so far frequently not available. How these gendered data can be access for research will be laid out in our presentation, along with a call for further research.

Gender, certification, tropical forest work

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133 - Social dimension of wildlife conservation and management

KG I - 1132 (Uni Freiburg)

IUFRO17-1381 **Social acceptability of pest management in UK forests: Does species and place matter?**

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Abstract: Attitudes towards wildlife management methods affect forest manager's decision-making in a number of ways. Not only do they constitute an integral element of some forest planning processes - formalised through stakeholder analysis and consultation - but presumptions about people's attitudes can also influence which management methods are used. For example, assumptions about public opposition to deer culling can reduce manager's willingness to cull, even if it risks compromising the wider landscape. Support and opposition for a particular management method is often contingent on local circumstances, for example: how a method is implemented and by whom, the overarching management objectives for the land in question, the juxtaposition of different methods (e.g. their relative priority or order in which they have been tried), and the effectiveness of a method in a particular setting. Moreover, stakeholders' attitudes towards particular management methods can vary markedly as a result of perceptions of a species (e.g. abundance) and connections to the place where management will occur. To identify the key factors influencing social acceptability of management measures we present findings from face-to-face interviews and surveys relating to four species (grey squirrels, feral pigs, rhododendron, oak processionary moth) considered by some to be pests in UK forests.

Forests wildlife management methods acceptability

KG I - 1132 (Uni Freiburg)

IUFRO17-1154 **Social relation between deer damage in forests and hunting culture for finding future directions of rural community**

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(1) Kyushu University, Fukuoka, Japan

Abstract: Forestry damage caused by *sika* deer has been a growing problem in Japan over recent years, and in 2014, the affected forest area reached around 7,100 ha. According to a survey by the Japanese Ministry of Agriculture, Forestry and Fisheries, there are over 3 million sika deer in Japan, and they are continuing to increase. Previous studies have pointed out that a major increase in the sika deer population is due to a reduction in the number of hunters; Japanese hunters are rapidly ageing. This study, on the other hand, aims to understand the opinions and attitudes of forest owners toward wild deer and the hunting culture present in local communities, and to suggest measures to solve the deer problem. Data collection was conducted through both a literature review and by interviewing forest owners around *Yabakei* in *Oita* prefecture, one of the areas severely affected by the deer. The authors took into consideration the age and occupational history of the forest owners. In addition, this study discusses the differences in attitudes toward wildlife and hunting rights between Japan and European countries, as well as future directions and appropriate measures to help reduce the problem of the sika deer.

KG I - 1132 (Uni Freiburg)

IUFRO17-1588 **Crop damages by wildlife and citizens' willingness to pay for wildlife conservation in protected areas in Korea - The case of Jirisan National Park**

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(1) Seoul National University, Seoul, Korea, Republic of (South Korea)

Abstract: To reduce the loss of biodiversity and to conserve ecosystems, the government of Republic of Korea has introduced regulation policies by designating protected area (PA). However, restrictions on land use activities in protected areas can create negative externalities which incur opportunity costs to land owners and damage local livelihoods. For social justice, the government should compensate local residents for their economic losses due to protected area policy. Local residents may be damaged by wildlife inhabiting protected areas while tourists may perceive more 'natural' recreational experiences through wildlife watching and photographing. The current compensation system for damages by wildlife is not appropriate. In order to assess the appropriate level of compensation for damages to local residents, it is necessary to estimate local residents' damages by wildlife in protected areas and potential tourists' willingness to pay (WTP) to manage protected area for wildlife conservation. We surveyed the 84 households in 6 villages nearby Jirisan National Park to estimate the wildlife damage to agriculture and forestry production. The amount of damage was 1,020 USD per household per year on average. Currently we are conducting additional survey of citizens' willingness to pay to protect wildlife in Jirisan National Park to design payment for ecosystem services (PES) for wildlife conservation.

wildlife conservation, wildlife damage, PES

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133 - Social dimension of wildlife conservation and management

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IUFRO17-1834 **Don't be afraid, my deer: Analysing the wildlife's landscape of fear caused by recreational activities to minimise conflicts**

Gantner, B.* (1); Brandenburg, C. (1); Marous, H. (1); Aufreiter, C. (2); Bauerhansl, C. (2); Daim, A. (3); Freudenschuß, A. (2); Hackl, J. (4); Hackländer, K. (3); Heckl, F. (4); Reimoser, F. (5); Salbaba, T. (2); Schadauer, K. (2); Schodterer, H. (2)

(1) Universität für Bodenkultur Wien, Inst. f. Landschaftsentw., Erholungs- u. Naturschutzplanung, Wien, Austria; (2) Austrian Research Centre for Forests, Wien, Austria; (3) Universität für Bodenkultur Wien, Institute of Wildlife Biology and Game Management , Wien, Austria; (4) Environment Agency Austria, Wien, Austria; (5) University of Veterinary Medicine, Vienna, Research Institute of Wildlife Ecology, Wien, Austria

Abstract: Wildlife populations are strongly influenced by recreational activities. This land use thus affects, among others, habitat use of wildlife in time and space. The sum of all land use types create a "landscape of fear" which might lead to wildlife damage in forestry and agriculture. In the ongoing project "Integrative sustainable wildlife management in alpine ecosystems" we study this "landscape of fear" in order to identify potential conflicts between land users and wildlife. The study area is a mountain near the city of Salzburg (Austria), where numerous recreational activities, e.g. hiking, skiing and paragliding are exercised regularly (whereas riding mountain bikes is prohibited but also done). As the activities are carried out in all seasons and at all times of the day and night, wildlife can be affected and especially ungulates can cause damage e.g. to protective forests. To research the influence on ungulate habitat use, temporal and spatial land use has been analysed on the scale of 1) the catchment area of the recreationists, 2) the hunting district itself and 3) crucial wildlife habitats and areas close to e.g. the feeding of game animals. Methods applied include 1) expert interviews, 2) analysis of volunteered geographic information (e.g. webshare services data) and 3) GIS-based modelling. Findings outline the contribution of recreational activities for the "landscape of fear" and its impacts on forestry and hunting. Finally, measures to minimise conflicts on all analysed scales will be developed. The study was carried out in cooperation with Mayr Melnhof-Forstverwaltung Salzburg and with financial support by the Austrian Research Promotion Agency, project number 846026.

wildlife, recreation, landscape of fear

KG I - 1132 (Uni Freiburg)

IUFRO17-3348 **Exploring human-nature relationships in Chile: a multi-stakeholder perspective to wildlife conservation management**

Silva-Rodríguez, E. (1); Cerda, C.* (2); Promis, A. (2); Briceño, C. (3); Bidegain, I. (4); Pantoja, J. (4); Razeto, J. (5); López Santiago, C. (6)

(1) Faculty of Biological Sciences Andres Bello University, Santiago, Chile; (2) Faculty of Forest Sciences University of Chile, Santiago, Chile; (3) Faculty of Veterinary Science, Santiago, Chile; (4) Faculty of Forest Sciences University of Chile, Laboratory of Socioecosystems Universidad Autónoma de Madrid, Santiago, Chile; (5) Faculty of Social Sciences University of Chile, Santiago, Chile; (6) Laboratory of Socioecosystems Universidad Autonoma de Madrid, Madrid, Spain

Abstract: How humans perceive nature is important for its management. For example, invasive species control may be seriously challenged if the species to be managed is valued by key stakeholders. Here we investigated social perceptions towards animals and plants, as held by different stakeholders in La Campana-Peñuelas Biosphere Reserve, Chilean matorral ecoregion. We elaborated black silhouettes of native and invasive animals (vertebrates and invertebrates) and plants (from herbaceous to trees) that were presented to research participants in face-to-face interviews. The questionnaire was conducted covering a broad range of local actors that represents the diversity of stakeholders present in the territory. Our preliminary results indicate that people perceive plants as very important and some invasive plants and animals are positively valued. The type of actor seems to be an important driver of social valuation. The study contributes to a better understanding of the ways members of the general public in the area reason about issues of wildlife management. Our data contributes to shed light on the factors that determine public acceptance of animal and plant species as well as management strategies targeting these species, and should facilitate the development of suitable ways to communicate wildlife management programs.

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IUFRO17-3852 **The society of large cities and its attitude towards controlling game populations in municipal forests**

Gruchala, A.* (1); Zasada, M. (1); Skorupski, M. (2); Jaminska, J. (1); Wierzbicka, A. (2); Krokowska - Paluszak, M. (2)

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Abstract: The administrative boundaries of many large cities include forest areas. These forests are usually owned by the cities and managed by special municipal services or companies. Due to their location, closely related to the presence of large human societies, forests fulfill primarily social, recreational and educational functions. Therefore, the approach to their protection and management, municipal forests nowadays create ecosystems stimulating the increase of game population. This increase is noticeable enough to society to cause, at least in part , a sense of danger.
In this paper we present the opinions of the citizens of two Polish cities (Warszawa and Poznan) on the impact of animals living in urban forests, on their daily lives, including their safety, needs, and the possibility and methods of regulation of the game populations' size. The research was done using a diagnostic survey performed in 2016 and 2017 on the representative samples of citizens. We discussed the differences in the approach to the problem between various groups of people.

animals, questionnaire, public preferences

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KG I - 1132 (Uni Freiburg)

IUFRO17-34 **Geospatial Approaches to the Assessment of Urban Forest Cover**

Bettinger, P.* (1); Merry, K. (1); Siry, J. (1); Bowker, J.M. (2)

(1) University of Georgia, School of Forestry and Natural Resources, Athens, United States; (2) U.S. Forest Service, Southern Forest Experiment Station, Athens, United States

Abstract: Urban canopy cover is an important metric that is often associated with the ability of a municipality to provide regulating ecosystem services to the people residing there. The ability to efficiently measure canopy cover across broad, complex landscapes is therefore important, as is the ability to assess changes that occur over time. This presentation will provide an assessment of numerous sources of remotely sensed information and methodologies helps to inventory, monitor, and judge the development potential of urban forests in a cost-effective and timely manner.

Urban forestry, canopy cover, sampling

KG I - 1132 (Uni Freiburg)

IUFRO17-301 **Stakeholders support for using urban forests to mitigate and adapt to climate change**

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(1) University of Georgia, Warnell School of Forestry & Natural Resources, Athens, United States; (2) USDA Forest Service, Southern Research Station, Athens, United States; (3) University of Tennessee, Department of Forestry, Wildlife, & Fisheries, Knoxville, United States

Abstract: Building local municipal and public support is important if actions to expand urban forests as part of climate change strategies are to be successful. We performed two surveys: 1) a nationwide survey regarding US mayors' prioritization of urban forests within the context of climate mitigation and adaptation actions and 2) a survey on households in Atlanta, GA, USA and their willingness-to-pay (WTP) for the expansion of urban forests to mitigate and adapt to climate change. We found that mayors are taking steps to increase urban greenery in tandem with climate change actions; however, motivating factors on whether climate mitigation or adaptation actions are taken is contingent on whether a mayor-council or council-manager form of government exists. A WTP analysis showed that Atlanta households are willing to pay $5.24 to $6.11 million over a five-year period. Residents who reside in higher tree canopy areas may be more willing to pay for urban forests more because they more readily benefit from the trees. Media preferences also play an important role in predicting the attitudes and preferences of climate change mitigation. Our research shows support for increasing urban forests and greenery to mitigate climate change among US mayors and urban residents.

cities; mayors; households; willingness-to-pay

KG I - 1132 (Uni Freiburg)

IUFRO17-3054 **Spatio-temporal patterns of carbon storage by urban forest: implications for CO2 emissions mitigation under China's rapid urban expansion and greening**

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Abstract: Understanding spatiotemporal dynamics of urban forest and its carbon storage is important for urban planning and management. However, as traditional field sampling methods are generally labor-intensive and time-consuming, spatial-temporal urban forest and its carbon storage data usually are extremely scarce. Our study explores the potential of estimating urban forest and its carbon storage spatiotemporally by using multitemporal Landsat TM imagery. In the study, normalized difference vegetation index (NDVI) obtained from TM image data in 2014 and urban forest carbon storage derived from field-based survey were implemented to develop the regression models to predict urban forest carbon storage in Changchun, China. And then NDVI correction models were established by normalizing the imagery (1984, 1995, 2005) to the 2014 TM image data in order to estimate spatiotemporal urban forest carbon storage. Finally, spatiotemporal urban forest carbon storage maps were produced from NDVI maps by using urban forest carbon storage predictive model. The results showed that NDVI could still be used as predictor for urban forest carbon storage. Urban forest coverage in Changchun was very dynamic from 1984 to 2014. Urban forest carbon storage was 68×103t, 129×103t, 167×103t and 224×103t of the entire study area in 1984,1995, 2005 and 2014. Urban forest and its carbon storage in the whole study area increased gradually from 1984 to 2014. In addition, urban forest carbon storage class distribution were all skewed toward low values in 1984, 1995, 2005 and 2014. But the frequency of higher urban forest carbon storage increased gradually from 1984 to 2014. Besides, urban forest and its carbon storage all show a definite gradient decreasing from suburban areas to urban center areas. The results demonstrate TM image has a relatively rapid and efficient capability for quantitative estimation of urban forest and its carbon stoage over urban areas.

Urban forest, Landsat TM, Carbon storage

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IUFRO17-3904 **Engaging and mobilizing citizens in preparing our urban forests for climate change - reviewing the role of mapping and visualization tools**

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(1) Faculty of Forestry, University of British Columbia, Vancouver, Canada; (2) Universidad Politecnica de Madrid Ciudad, Madrid, Spain

Abstract: Climate change is likely to adversely affect people where they live, and the urban forest they benefit from. Urban forests are also threatened by urbanization and densification. Many cities like Vancouver in British Columbia are experiencing declines in tree canopy and ecosystem services, that could help citizens cope with climate change. To develop resilient, low-carbon communities that remain attractive and healthy for residents, citizen involvement is crucial, due to the key role of private land and need for citizen stewardship to supplement municipal management efforts. However, citizens tend not to connect their behaviours (e.g. removing trees in gardens) to future consequences (e.g. shrinking tree canopy and cooling capacity citywide). This presentation reviews citizen education & engagement tools with potential to build these personal connections to climate change and urban forestry, and ultimately influence social norms and behaviours. It focuses on compelling mapping and visualization tools that can engage local citizens and youth, reviewing precedents and recent research that apply these tools at various levels (eg. high school classes, university courses, and community engagement processes). It considers the potential to adapt professional tools (e.g. iTree, landscape architectural renderings) to such uses, and provides recommendations for practice based on lessons learned.

social mobilization, visualization, urban forest

KG I - 1132 (Uni Freiburg)

IUFRO17-1636 **Urbanization and forest type effect on landscape patterns, structural and taxonomic attributes and services of urban forests in Changchun, China**

He, X.* (1)

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Abstract: Urban forest, an important part of urban ecosystem, can play important role in delivering multiple services and functions. However, with rapid urbanization, urban forest landscape patterns, attributes and services may be correspondingly changed dramatically. In this study, remote sensing technology and field survey were combined to study the effects of urbanization and forest type on landscapes, attributes and services of urban forests in Changchun. The results showed that Patch Density, Landscape Shape Index, Interspersion & Juxtaposition Index, Tree Density, Canopy Density, Species Richness (SR) and He' all increased with urbanization intensities, and had increased by 162%, 60%, 44%, 37%, 50%, 85%, 84% from low to heavy urbanization area, respectively. On the contrary, Mean Euclidian Nearest Neighbor Distance metric and Health condition had decreased by 12% and 37%, respectively. Significant associations between landscape patterns and attributes of urban forests indicated that regulations of fitter landscape metrics were possible to improve urban forest services. Furthermore, there were obvious differences for landscapes, attributes and services among types of urban forests. Attached forest had the highest PD, SR and He', whereas production and management forest (PF) had the lowest ones. Based on the 10/20/30 "rule", the diversity should be increased at the species, genus, and family levels for PF. Moreover, Landscape and relaxation forest had the highest Carbon density with 5.41 kg/m2, while PF had the lowest value with 1.46 kg/m2. These differences demonstrate that urban forest type is an important factor needed to be considered when urban forest planning and services estimating.

urban forest, attributes, landscapes, services

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37 - Intact forest landscapes in the context of voluntary certification of forest management.

KG I - 1015 (Uni Freiburg)

IUFRO17-1328 **High conservation values and intact forest landscapes - changes and challenges for certified operations**

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(1) Forest Stewardship Council , Bonn, Germany

Abstract: Introducing Session 37 of the congress, the paper will present the status of discussion about FSC requirements for the certification of forest management with 'High Conservation Values' (HCV) and especially for protecting 'Intact Forest Landscapes' (IFL). IFLs are territories with forest and non-forest ecosystems minimally influenced by human economic activity and with no signs of habitat fragmentation, with at least 500 km2, present in 64 countries. The sheer size of an IFL can have financial implications for commercial certified forest operations when these operations are required to manage IFL cores ensuring to maintain and enhance intactness of IFLs.

The authors will lay out, how HCVs in general are managed in FSC certified operations, and in which regions/countries IFLs are of particular relevance for forest management standard development.
Alternative models for management of IFLs and on landscape level will be presented as work in progress. Strategies for process development, tools and key stakeholders (i.e groups with partly conflicting interests in forest management, such as environmentalists, concessionaires, and Indigenous Peoples) to define IFLs and to monitor their intactness will be presented, as well as incentives for forest managers with HCV to engage in certification processes.

forest management certification (FSC)

KG I - 1015 (Uni Freiburg)

IUFRO17-1875 **Impacts of logging roads on intact forest landscapes in the tropics**

Kleinschroth, F.* (1); Gourlet-Fleury, S. (1); Healey, J. R. (2)

(1) CIRAD, Forêts et Societés, Montpellier, France; (2) Bangor University, School of Environment, Natural Resources and Geography, Bangor Gwynedd, United Kingdom

Abstract: Road networks are growing globally, especially in tropical countries, allowing human access to remaining Intact Forest Landscapes (IFL) that are refuges for biodiversity and provide globally important ecosystem services. Selective logging is now widespread in tropical forests, acting as one of the main drivers of road network expansion, with logging roads often being considered door-openers and conduits for human impacts. The protection of road-free IFL is high on the biodiversity conservation agenda, a challenge for logging concessions certified by the Forest Stewardship Council (FSC). However, the impacts of logging roads can be highly variable depending on road use and management. In a logging-hot-spot of the Congo Basin, only 12% of all roads were permanently open, with all others becoming quickly revegetated and inaccessible. Taking limited road persistence into account, we analyzed how road networks in FSC certified concessions affected IFL. We followed the spatial and temporal dynamics of logging roads, comparing roadless space in certified and non-certified logging concessions inside and outside areas declared as IFL in the year 2000. We found that roadless space decreased rapidly in IFL, notwithstanding FSC certification, highlighting the urgent need for measures to safeguard ecological corridors between protected areas and remaining intact forests. Logging concession certification by FSC might play a key role in conserving forest connectivity by strategic road network planning. Forest management should make the preservation of large connected forest areas a top priority by effectively monitoring - and limiting - the occupation of space by roads that are accessible at the same time. Given the strong dynamics between the impacts of different types of roads, we challenge the static definition of IFL based on a buffer around any road ever detected.

Roadless areas, IFL, Conservation, Congo Basin

KG I - 1015 (Uni Freiburg)

IUFRO17-3290 **Intact Forest Landscapes and FSC certification in Brazilian Amazon: challenges to sustainable management**

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(1) ESALQ/USP, Piracicaba, Brazil; (2) PGDR/UFRGS, Ibiuna, Brazil; (3) WWF, Brasilia DF, Brazil; (4) Imaflora, Piracicaba, Brazil

Abstract: Maintenance of large natural forest landscapes is paramount to protect biodiversity, but also to reduce carbon emissions from deforestation and forest degradation. Intact Forest Landscape (IFL) is defined as an unbroken portion of natural ecosystems within the current global forest extent, showing no signs of significant human activity, and vast enough to effectively maintain biodiversity. Despite deforestation dynamics in the Amazon, remaining forests cover around three million km2 in Brazilian Amazon. IFL area in Brazil is estimated at 2,3 million square kilometers. Native forests certified by FSC cover an area of 1,5 million ha. As part of an effort to contribute to the debate on best strategies to ensure IFL protection and sustainable forest management, the present study analyzed different spatial data sources to enlighten the scale and territorial domains where IFLs are found in Brazilian Amazon. We also demonstrate the proportion of IFLs within certified Forest Management Units (FMU). In addition to these analyses, we performed a survey to reveal the challenges to manage IFLs from an FSC certificate holder and expert perspective. Results showed a significant proportion of IFLs within public lands (national forests and indigenous lands). Also, the IFL area within certified forests is located more in federal or state forest concessions than in private lands. From an FSC certificate holders and experts perspective, the primary challenge is how to develop the IFL portions while maintaining its values and ensuring protection. While market for ecosystem services and non-timber forest products are uncertain, Reduced Impact Logging (RIL) is defended as one of the best management strategies to ensure sustainable forest management within IFL areas.

Brazilian Amazon, IFL, RIL, native forests,FSC

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37 - Intact forest landscapes in the context of voluntary certification of forest management.

KG I - 1015 (Uni Freiburg)

IUFRO17-1494 **The effectiveness of legal protection and FSC certification as instruments for slowing degradation of Intact Forest Landscapes**

Potapov, P.* (1); Laestadius, L. (2); Yaroshenko, A. (3); Thies, C. (4); Turubanova, S. (1); Hansen, M. (1)

(1) University of Maryland, College Park, United States; (2) Laestadius Consulting, LLC, Silver Spring, United States; (3) Greenpeace Russia, Moscow, Russian Federation; (4) Greenpeace Germany, Hamburg, Germany

Abstract: Intact Forest Landscapes (IFLs) are large, unbroken areas the forest zone with no signs of human activity. IFLs store carbon, sustain natural biological diversity, and provide a multitude of other ecosystem functions. Their high conservation value is augmented by the fact that they cannot be replaced as reference areas for understanding global change and cannot be restored by artificial means. Remaining IFLs are unevenly distributed across the world, their area shrinking fast and at an increasing rate. Industrial timber extraction is the primary global reason for loss of IFL area. Logging causes alteration while roads and other infrastructure cause fragmentation. Together, they initiate a cascade of knock-on effects that transform the landscape and erode its conservation values. We studied the effect of legal protection and FSC certification on IFL area change within comparable landscapes in countries in the tropical, temperate, and boreal biomes. Protected areas (IUCN categories I-III) were effective in slowing the IFL area loss from timber harvesting but less effective in limiting the expansion of agriculture. Certification had a negligible effect on the rate of IFL area loss and even stimulated IFL fragmentation in some countries.

Intact forest landscapes, FSC, Protected areas

KG I - 1015 (Uni Freiburg)

IUFRO17-3726 **Driving progress towards best practice in IFLs: the role of transparency**

Eves, C.* (1)

(1) Zoological Society of London, London, United Kingdom

Abstract: Forest certification has an important role to play in preserving and ensuring the sustainable management of Intact Forest Landscapes (IFLs). However, the spread of certification in tropical zone countries - which are home to a significant proportion of IFLs - has been limited to date. Barriers to the spread of certification include issues of land tenure, the costs of certification, and access to markets for certified products. Progress towards best practice management is nonetheless being made by some tropical producers of forest products. If the world's remaining IFLs are to be protected, such actors must be supported and encouraged in their journey towards full certification.

SPOTT is an initiative of the Zoological Society of London (ZSL) that provides information on the commitments to best practice made by commodity producers to their investors, so placing pressure on producers to improve their commitments and so reduce the Environmental, Social and Governance (ESG) risks associated with their operations. Given the threats to IFLs and other critical forest areas posed by logging activities and the expansion of industrial plantations, ZSL is expanding SPOTT to assess timber, pulp and paper companies operating in priority tropical areas, including IFLs.

This presentation will demonstrate how the newly developed SPOTT Timber, Pulp and Paper model assesses commitments to environmental and social best practice among major forest product producers, how it uses this information to drive change through engagement with producers and their investors, and how it can provide an incentive for commodity producers to move towards full certification and the protection of IFLs.

IFLs; certification; transparency; commodities

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IUFRO17-4000 **Creating incentives for the protection of intact forest landscapes using new certification tools for ecosystem services**

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(1) Forest Stewardship Council (FSC) International, Bonn, Germany; (2) Center for International Forestry Research (CIFOR), Bogor (Barat), Indonesia

Abstract: In this paper we introduce new benefit models that could be used to incentivize the protection and responsible management of intact forest landscapes using Forest Stewardship Council's (FSC) new certification tools for ecosystem services.

Traditionally forests have been seen as sources of goods and their management has focused on timber production. The rise of the concept of ecosystem services has meant changes in the way forests are seen but so far the implications to their management have been limited. Despite limited markets for ecosystem services provision so far, certification standards have foreseen a potential market niche and have moved into certification of ecosystem services. FSC has been developing new tools dedicated to ecosystem services to deliver additional monetary and non-monetary benefits for certificate holders and communities. The approach could be of particular importance for intact forest landscapes where alternative economic models to degradation and loss are sorely needed. We will apply the lessons from extensive pilot testing of these new tools to intact forest landscapes and address the question: can green investments and payments for ecosystem services tip the balance towards responsible forest management, and sustainable livelihoods?

IFLs, ecosystem services, payments, incentives

All Division 6 (Social Aspects of Forests and Forestry) Meeting

69 - Urban forestry for quality of life - the impacts of research on everyday practices

KG I - 1199 (Uni Freiburg)

IUFRO17-2586 **Urban forest as biodiversity hotspots: dead wood, birds and human perception**

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Abstract: Humans have disproportionally settled in areas with ecosystems that on a global level are considered to be biodiversity hotspots. Remnants of natural occurring forests in cities provide very good prerequisites for high biodiversity. However, urban forests are being constantly fragmented and more than 50% are smaller than 2 ha in many European cities and species in need of larger habitats will decline. Further, forests are managed to secure safety for visitors by removal of shrubs and dead wood and thus reducing substrates important to many species. Here we overview the linkages between the prerequisites for biodiversity in urban forests and how people perceive urban forests with high biodiversity.

In Sweden the urban-fringe forests have higher occurrence of dead wood and deciduous trees than comparable forests outside cities. This creates unique habitat prerequisites for species that are linked to these substrates in cities. In Swedish cities the diversity of bird species is equally high along an urban rural gradient although the species characteristics differ. However, management of urban forests can affect abundance and foraging success of avian insectivores. Urban forests often provide higher overall species richness than parks. The species richness could also be linked to human perception where urban forests with high diversity have more aesthetical values than parks with less diversity. Bird song of common urban forest birds increased positive perceptions of urban settings and even more so when more species were singing. Further, people who consider themselves being "highly nature oriented persons" perceived higher positive values in urban forests than people consider themselves "less nature oriented persons".

It is however possible to manage urban forests to provide high security as well as biodiversity. It is important to conserve urban forests for species richness per se as well as the increased positive experiences to city inhabitants that it provides.

biodiversity, urban woodlands, species richness

KG I - 1199 (Uni Freiburg)

IUFRO17-386 **Strategic interaction in municipal governments' provision of public green spaces: a dynamic spatial panel data analysis in transitional China**

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(1) Department of Geography, The University of Hong Kong, Hong Kong, Hong Kong

Abstract: With the increasing recognition of urban green space contribution to residents' social, economic and environmental welfare, municipal governments might provide public green spaces (PGS) in a strategic manner to make their cities more attractive compared with their neighbours so that more investments and potential residents can be attracted. Based on panel data of China's prefecture cities from 2002 to 2014, this study explores the strategic interaction amongst municipal governments in PGS provision. A dynamic spatial panel data model with city and time-period fixed effects is applied. The results reveal the existence of strategic interaction amongst municipal governments: cities will mimic their neighbouring cities. Economic development, population growth, and land availability exhibit strong positive direct effects on PGS provision in short time span, suggesting a possible yardstick competition during short political cycle periods. Whereas a wage increase has a positive direct effect on PGS provision in the own city, it has a negative spillover effect in neighbouring cities, which might be attributed to the inward migration of skilled worker from neighbouring cities to where better green amenities can be provided. This research offers practical insights for effective urban planning, emphasizing the need of long-term plans for PGS provision in transitional China.

urban forest; dynamic spatial panel data model

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IUFRO17-103 **Innovative urban forestry governance in Melbourne?: unpacking the implications of "green place-making" as a Nature-Based Solution**

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(1) University of Copenhagen, Landscape Architecture and Planning, Frederiksberg, Denmark; (2) City of Melbourne, Melbourne, Australia

Abstract: A nature-based approach to climate resilience aims to challenge and re-frame conventional environmental management methods by refocusing solutions from technological strategies to socio-ecological principles such as human well-being and community-based governance models, thereby improving and legitimizing the delivery of ecosystem services (ES). There are however many challenges to applying a socio-ecological agenda to urban climate resilience and thereby re-framing ES delivery as community and people focused. While resilience thinking, as represented by an urban green infrastructure approach to climate adaptation, offers a dynamic and holistic approach to human and environmental change, it problematically assumes that social and ecological dynamics can be modeled similarly and thereby can mask the possibility to ask important questions about the role of power and culture in the adaptive capacity of green infrastructure and delivery of ES. Urban environmental governance is challenged in this sense to move from a scientific and technocratic "view from nowhere" to an enriched socio-cultural view that is deeply place-based. In this paper we aim to shed light on the role of diverse, complex and contested rationalities in urban environmental governance, management, and planning and thereby open a discussion into how local knowledge is understood and incorporated into ecological decision-making processes. We do this by applying a socio-cultural place-based lens to the process of urban re-naturing, examining the city of Melbourne's approach to governing an internationally-acclaimed urban afforestation campaign. Through this inquiry we hope to shed light on community preferences for institutional arrangements of UGI-planning and ES delivery but also provide nuanced understandings of the nested social and political processes involved in a nature-based approach to urban climate resilience.

urban forestry; governance; place making

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69 - Urban forestry for quality of life - the impacts of research on everyday practices

KG I - 1199 (Uni Freiburg)

IUFRO17-1140 **Municipal Forestry and Management in the United States: An Urban & Community Forestry Census of the United States**

Hauer, R.* (1)

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Abstract: It's been 20 years since the last update of the Municipal Forestry, Tree Activities, and Management in the United States occurred. This talk will provide the latest baseline status through an Urban Forest Census on how communities manage trees in the United States. Over 1750 communities were asked to participate to assess urban forest programs, operations, budgets, management, activities, and policies for municipalities in the United States. The study will illustrate the current capacity to manage urban forest populations. It closes a 20 year gap since the last assessment of municipal urban and community forestry programs last done in 1993. Thus, the Urban Forest Trend Analysis will describe any discernible patterns that occur for communities between present and 1993. The project also carries on the seminal work first done in 1974 and repeated in 1980 and 1986. This gives a 40-year longitudinal analysis of community tree management. The involvement of public workers, private contractors, and volunteers in tree management is explored. Thus, this presentation will provide the latest in the current and long-term examination of urban and community forestry management in the United States. Key findings address: employee salaries, costs to maintain urban forests, effects of emerald ash borer on municipal budgets, allocation of budgets towards tree activities, policies and ordinances, volunteer and urban forest management, contractors and urban forest management, tree risk management, storms and preparedness, tree diversity, and systematic management approaches.

Census, Municipal Forestry, Trends, Urban Forestry

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IUFRO17-1406 **The Role of Urban Forestry in delivering Resilient Urban Futures, with a focus upon the Leeds City Region, UK.**

Simson, A.* (1)

(1) Leeds Beckett University, Art, Architecture + Design, LEEDS, United Kingdom

Abstract: The c.21st is the century of the city, as the world continues to urbanize at an increasingly unsustainable rate. Cities are complex environments, and whilst many of them exhibit unique cultural and social factors, they also also share many common attributes. These include the need to have a successful economy, a viable urban identity, social cohesion and a good quality of life for their people. In order to deliver these attributes, there is much political pressure to develop the concept of the 'Sustainable Compact City', but there is now an increasing canon of research that suggests that such compact cities may not be quite as sustainable as they are claimed to be.The speed of environmental, economic and social change suggests that what we need are 'Resilient Cities' - cities that comprise communities that are 'ready for anything'.

One way of helping to deliver cost-effective, resistant urbanism that is rapidly gaining political traction is for a city to have a designed, viable Urban Green Infrastructure [UFI]. The concept of Urban Forestry is acknowledged as being centre stage to delivering UGI, and the economic, societal, cultural and environmental benefits that accrue from incorporating urban forestry into both new and retro-fitted urban areas have been quantified and evaluated, and proven to actively assist in delivering resilient urban futures.

This presentation will briefly consider some of the significant research that has taken place into the contribution that urban Forestry can make to Resilient Urban Futures, and specifically how this 'Research into Action' is being applied in the Leeds City Region[LCR]. The LCR is one of only two City Regions in the UK, covers an area of 5700km2, has a multi-cultural population of over 3 million people and requires 10 Local Administrations to work together. UGI, with urban forestry at the helm, has been identified as being a central policy for the LCR that will enable it to deliver resilient urban futures for its peoples.

resilient urbanism, urban forestry, Leeds City

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IUFRO17-2031 **Urban forestry and human health**

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Abstract: With the increasing urbanisation, changing disease scenario, and current predictions of climate change impacts there is a need for strategies on how to provide healthy and sustainable cities, now and for the future. The recently coined concept, Nature-based solutions (NBS) refers to actions that are inspired by, supported by, or copied from nature, and that are designed to address a range of environmental challenges in an efficient and adaptable manner, while at the same time providing economic, social, and environmental benefits. In combination with the increasing evidence on public health benefits of exposure to natural environments, there is an impetus to explore how this knowledge could be framed within the NBS concept, to improve implementation of evidence. This study presents a systematic review of reviews on associations between public health and natural environments in relation to pathways - sociobehavioural/cultural ecosystem services (e.g. stress and physical activity) and regulating ecosystem services (e.g. heat reduction) - or defined health outcomes (e.g. cardiovascular mortality). By also reviewing existing literature on NBS and health, we phrase the results within the NBS context, providing guidelines on how public health and well-being could be integrated into design, management and planning of NBS for resilient and liveable urban landscapes.

systematic review, NBS, heat stress, public health

All Division 7 (Forest Health) Meeting

198 - Forest biodiversity and resistance to natural disturbances

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1798 **Experimental effects of forest diversity on bird insectivory at the global scale**

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Abstract: Trophic interactions between predators, phytophagous herbivores, and plant communities vary across ecosystems. For example, insectivorous birds have been shown to be important control agents of insect herbivores, significantly reducing herbivore abundances, leaf area damage and improving plant productivity. However, despite accumulating evidence for positive effects of habitat diversity on insectivory and, growing interest in sustainable and economical pest control methods, few studies have explored interactive effects of vertical and horizontal diversity. Those that have have largely focussed on small spatial scales, neglecting the impact of large-scale factors like climate. To address this, we used sites in the global network of tree diversity experiment (TreeDivNet), located across Europe, China and North and Central America. In each, predation rates by different taxonomic groups were assessed using dummy caterpillars installed on trees between May and September 2016 and repeatedly checked for damage. Effects of tree species richness on predation rates were then examined to determine their magnitude and consistency given differences in latitude and climate between sites. Further surveys of insect prey and their predators were used to shed light on underlying mechanisms, unravelling functional responses, predator abundance and predator diversity as drivers of insectivory. Taken together, our results provide novel insight into the factors influencing top-down control of insect pests in forests and link species diversity, species interactions and levels of ecological function at the global scale.

PARTICIPATING TREEDIVNET EXPERIMENTS (Co-Author list Pending):
BIOTREE, BiodiversiTREE, BEF-China, Climate-Match, ECOLINK, FORBIO, IDENT-Freiburg, IDENT-Montreal, IDENT-Sault-Ste-Marie, ORPHEE, Satakunta, UADY

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-442 **Using seedlings with select traits to lower risk of herbivore browsing**

Griess, V.* (1)

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Abstract: Western redcedar (WRC) (Thuja plicata) is of outstanding economical and cultural value for BC's coastal forests. WRC is actively harvested, however, successfully replanting it remains a challenge. In coastal BC, a major threat to young WRC stands is ungulate browsing, and an estimated $25 million are spent annually on protective measures in the Pacific Northwest and coastal BC, yet those measures are falling short of alleviating the problem. Generally, cones are used to physically protect the seedlings, however, they are time consuming to install and don't always serve their function.
In past years it was discovered that varying levels of monoterpenes in seedlings are related to ungulate browsing preferences: they actively select to forage on seedlings with low levels of foliar monoterpenoids, while avoiding plants with higher levels. These findings have led to the establishment of a breeding program for browse resistant WRC overseen by the Ministry of Forests, Lands, and Natural Resource Operations. The program has shown much potential, however the silviculture and management of stands of the according seedlings has not yet been addressed sufficiently. If only high monoterpene seedlings are available, deer are likely to start foraging on alternative species such as Douglas fir (DF) (Pseudotsuga menziesii), commonly planted in mixture with WRC and ultimately, are likely to also be feeding on those seedlings that are initially less attractive. We established 5 research plots of 1 ha each with a mixture of normal class A orchard seedlings, enhanced WRC seedlings and class A DF orchard seedlings in UBC's research forest in 2016. On each plot we survey browsing damage, seedling growth and a number of other relevant variables, until the seedlings reach a specific height (ca. 1.3m), therefore outgrowing the height that is browsed by deer. We will be presenting first results, as well as an economic analysis of our initial findings.

douglas fir, thuja plicata, cedar, browsing, deer

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198 - Forest biodiversity and resistance to natural disturbances

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3013 **Tree diversity: Indirect effects on insect performance**

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(1) Swedish University of Agricultural Sciences, Department of Ecology, Uppsala, Sweden

Abstract: Diversity at tree level reduces competition between conspecifics, potentially leading to more vigorous trees in more diverse forest stands. The reduction in competition could have an effect on the host plant quality from the perspective of an insect herbivore, affecting the performance of insects on their host plant. As insect performance involves life history traits such as survival, weight and fecundity, host plant quality effects may be translated to the population level. Host plant quality is often linked to the C:N ratio of foliage and the presence of defense chemicals. If the quality of the trees is affected by growing in mixtures, this relationship needs to be investigated to fully understand the effects of forest diversification on insect population dynamics.

In order to study the relationship between plant quality and tree diversity we investigated the performance of the European pine sawfly (Neodiprion sertifer) in mixed and monoculture stands. Larvae of the sawfly were grown on selected pine trees protected from natural enemies. Cocoons were weighed as this measure is related to fecundity. Needles were collected and analyzed for carbon and nitrogen content.

We found no direct difference between mixed and monoculture stands (i.e. average pupal weight is equal). But the relationship between pupal weight and carbon content (%) seemed to decline more steeply in mixed stands compared to monocultures. In addition, the variability in weight is higher among larvae grown on trees in mixed forest stands compared to monocultures, and this variability increases with nitrogen content of the needles.

One conclusion is that the performance of the European pine sawfly is less variable in monocultures compared to mixed stands. A question we will attempt to answer in the presentation is whether these patterns are consistent throughout the life cycle and what this could mean for population fluctuations in forest stands with different levels of tree diversity.

Forest, sawfly, outbreak, plant defense

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-4015 **Role of multiple stressors on crown dieback & growth sensitivity of European beech (Fagus sylvatica L.) trees under recurrent droughts**

Chakraborty, T.* (1); Saha, S. (2); Reif, A. (1)

(1) Chair of Site Classification and Vegetation Science, University of Freiburg, Freiburg, Germany; (2) Chair of Silviculture, University of Freiburg, Freiburg, Germany

Abstract: How recurrent droughts are linked to growth response in European beech trees with contrasting water availability in forests, and when increasing crown die-back swerve to death had received inadequate attention. We researched how soil water stress together with climatic drought impacted crown die-back and annual growth of European beech trees in near-natural temperate forests of Germany and Switzerland. We quantified soil water storage capacity (AWC) together with other biotic and abiotic stressors to find their influence on crown die-back. Additionally, we examined if any threshold on crown die-back exists in beech trees. We used 65 years of tree rings and climate data for relating growth sensitivity to drought under contrasting soil water stress. Increase in AWC, tree species diversity, light availability and plant height reduced crown die-back; more prominently in the upper part of the crown. Neighbourhood interactions facilitate vitality of beech trees by reducing die-back. A mortality threshold was found at 58% of crown die-back. Resistance and resilience of annual growth to recurrent climatic drought were higher in less-dry than dry plots, with opposite trend in recovery. We recommend to maintaining a diverse forest in drought gradients to mitigate the impacts of drought on beech trees.

Mortality threshold, resilience, species diversity

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3368 **Does biodiversity confer resistance to biological invasions?**

Brockerhoff, E. (1); Meurisse, N.* (2); Jactel, H. (3); Kimberley, M. (2)

(1) Scion (New Zealand Forest Research Institute), Forestry Building, Christchurch, New Zealand; (2) Scion (New Zealand Forest Research Institute), Private Bag 3020, Rotorua, New Zealand; (3) INRA , UMR BIOGECO, Cestas, France

Abstract: Biodiversity plays an important role in the functioning of ecosystems and the provision of ecosystem services. The 'diversity-invasibility hypothesis' predicts an inverse relationship between the diversity of habitats and their invasibility, and several studies consider 'invasion resistance' an ecosystem service that is related to biodiversity. However, the results of experimental and observational studies are decidedly mixed, depending on the spatial scale and trophic level of studies.
In this presentation we will review the theoretical assumptions underlying the hypothesis and possible explanations for findings that do not conform. We will also discuss the relevance of the 'diversity-invasibility hypothesis' for planted forests. These represent a growing proportion of the world's forests, and because they are typically managed as single-species stands, and are often planted with exotic tree species, their contributions to the provision of vital ecosystem services is a growing concern. For example, given their low level of tree species richness, planted forests would be expected to be particularly susceptible to invasions by tree pests. There are various opportunities for enhancing biodiversity of planted forests and their capacity to resist biological invaders. Suggestions for their diversification will be discussed including the use of species mixtures at the stand and landscape scales and the planting of species-rich buffer zones surrounding planted stands.

ecosystem service, biodiversity, invasibility

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198 - Forest biodiversity and resistance to natural disturbances

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-486 **Does forest diversity reduce wind damage risk?**

Gardiner, B.* (1); Jactel, H. (2); Orazio, C. (1); Kamimura, K. (3)

(1) EFI Atlantic, Cestas, France; (2) INRA, Cestas, France; (3) Shinshu University, Nagano, Japan

Abstract: Wind is the most important disturbance in European forests but is predicted to continue to increase because of current forest management practices and the changing climate. A particular issue is the increasing use of single species or clonal plantation forestry using fast growing and often exotic species. These increasingly uniform forests have a high potential to be severely damaged by strong winds, and in addition are increasingly vulnerable to pests and diseases. However, there have been a number of studies in the past that have suggested that having more diverse forests enhances forest resistance to natural disturbances including wind damage. This increased diversity can be the result of both increased species diversity and increased structural diversity. In this paper we will examine the evidence for the stability benefits of forests with high tree and stand diversity, we will discuss the potential mechanisms for the increased wind stability of diverse forests, and we will discuss how forest management might be modified to adapt and mitigate the increasing threat of storm damage. We will also discuss the interactions between wind damage and other types of disturbance such as bark beetles and fire and how forest diversity can mitigate these interactions. Evidence will be presented from statistical analysis of observed wind damage resulting from major storms in Europe, wind tunnel studies with different configurations of model forests, field measurements of the wind loading on trees growing under different silvicultural systems, and simulations with mechanistic models working at the individual tree level.

Wind damage diversity

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-371 **Bottom-up and top-down effects of tree diversity on insect herbivory on pedunculate oak**

Castagneyrol, B.* (1); Bonal, D. (2); Damien, M. (3); Jactel, H. (1); Meredieu, C. (1); Muiruri, E. W. (4); Barbaro, L. (1)

(1) INRA, UMR BIOGECO, Cestas, France; (2) INRA, Champenoux, France; (3) Univ. Rennes, Rennes, France; (4) RHUL, Egham, United Kingdom

Abstract: Associational effects describe the lower (associational resistance) or greater (associational susceptibility) risk of herbivore attack to a plant growing among heterospecific rather than conspecific neighbours. The relative contribution of bottom-up and top down forces remains poorly understood. We particularly lack knowledge on the effect of abiotic constraints such as drought on the strength and direction of these effects.

We measured insect herbivory on pedunculate oak (Quercus robur), alone or associated with birch, pine or both in the ORPHEE experiment, while irrigating half of the plots. We tested three potential mechanisms of associational effects: (i) bottom-up effects of neighbours on oak accessibility to herbivores, (ii) indirect effects of oak neighbours on the expression of leaf physical and chemical traits, and (iii) indirect effects of oak neighbours involving greater top-down control of herbivores by predators.

Insect herbivory was lower in oak-birch mixtures than in oak monocultures or any other mixture, regardless of water availability. Yet, oaks were smaller than birches and pines and were more apparent in monocultures than in any mixture. Herbivory decreased with leaf C:N ratio, but it was the only measured trait that did not vary with the identity of oak neighbours. Despite greater rate of attacks on dummy caterpillars in irrigated plots, predation and herbivory were uncorrelated.

Our study shows that neighbour-mediated changes in leaf traits, apparency or predation are poor predictors of herbivory. We suggest that reduced herbivory in oak-birch mixtures resulted from a 'diversion effect', herbivores being diverted from oaks by taller, more apparent birch neighbours.

Associational effect; Biodiversity; Climate change

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-456 **Contrasting vulnerability and resilience to drought-induced defoliation in mixed versus pure stands.**

Sousa-Silva, R.* (1); Van Meerbeeck, K. (1); Van de Peer, T. (1); Sioen, G. (2); Laurent, C. (3); Ponette, Q. (4); Verheyen, K. (5); Muys, B. (1)

(1) KU Leuven, Department of Earth and Environmental Sciences, Leuven, Belgium; (2) Research Institute for Nature and Forest, Geraardsbergen, Belgium; (3) Service Public de Wallonie, Département de la Nature et des Forêts, Namur, Belgium; (4) Université catholique de Louvain, Earth and Life Institute - Environmental Sciences, Louvain-la-Neuve, Belgium; (5) Ghent University, Forest & Nature Lab, Gontrode, Belgium

Abstract: Drought is one of the most important climate-related events through which rapid ecosystem changes can occur as it affects the survival and function of existing forests. The impacts of these changes become evident during regular monitoring efforts of tree health, such as those commonly undertaken in the ICP Forests monitoring plots.
In this study, we revisited the trends in defoliation of Belgian monitoring plots, and hypothesized that the effects of climate-related vitality loss are tempered in mixed stands in comparison to monocultures. Three main European species were considered: European beech, sessile oak and pedunculate oak, growing in pure and mixed stands, which allowed us to test for species identity and diversity effects in terms of forest defoliation response to drought, from 1988 to 2015. Within the covered period, the most extreme drought episodes were always followed by defoliation peaks. Our results also indicate that sessile oak is more tolerant to drought than beech; but mixed beech has the quickest recovery and was significantly more resilient than in pure stands.
Finally, the higher resistance and resilience to episodic drought stress of sessile oak, both in pure and mixed stands, provide additional arguments for a preferential choice of this species as a climate change adaptation strategy.

crown condition defoliation drought tree diversity

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300 - Pine pitch canker - strategies for management of Gibberella circinata in greenhouses and forests

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IUFRO17-3035 **COST Action FP1406: Pine pitch canker - strategies for management of Gibberella circinata in greenhouses and forests (PINESTRENGTH)**

Diez, J. J.* (1); Martín, J. (1); Ioos, R. (2); Vainio, E. (3); Vasaitis, R. (4); Fernandez, M. (1); Hantula, J. (3); Capretti, P. (5); Vettraino, A. M. (6); Raposo, R. (7); Vannini, A. (6); Dogmus, T. (8); Alves, A. (9); Vasic, V. (10); Vasconcelos, M. (11); Woodward, S. (12)

(1) University of Valladolid, Plant Production and Forest Resources, Palencia, Spain; (2) ANSES. Unité de Mycologie, Malzéville, France; (3) LUKE, Vantaa, Finland; (4) Swedish University of Agricultural Sciences, Uppsala, Sweden; (5) University of Firenze, Firenze, Italy; (6) DIBAF, Viterbo, Italy; (7) INIA, Madrid, Spain; (8) Suleyman Demirel University. Faculty of Forestry, Isparta, Turkey; (9) CESAM, Aveiro University, Aveiro, Portugal; (10) Institute of Lowland Forestry and Environment, Novi Sad, Serbia; (11) Universidade Católica Portuguesa, Porto, Portugal; (12) Institute of Biological and Environmental Sciences, Aberdeen, United Kingdom

Abstract: Fusarium circinatum (teleomorph: Gibberella circinata) was first detected in North America, since when the pathogen has spread into Central and South America, South Africa, Asia and, more recently, Europe. F. circinatum is now considered the most important pathogen affecting Pinus seedlings and mature trees in many countries globally; asymptomatic seedlings may be planted out, resulting in very serious losses in forests. The main aim of PINESTRENGTH is to establish a European-focused network to increase knowledge of the biology, ecology and pathways of spread of F. circinatum, to examine the potential for the development of effective and environmentally-friendly prevention and mitigation strategies and to deliver these outcomes to stakeholders and policy makers. To that end, a multidisciplinary approach is being taken, including researchers, forest managers and policy makers from 35 countries to date. Furthermore, any interested party is encouraged to join this COST Action, participating in some of the six Working Groups (WG1 The pathogen-diagnosis, WG2 Interactions with other forest pests and pathogens, WG3 Pathway of disease spread, WG4 Pest risk analyses, WG5 Management of the disease in forest and nurseries and WG6 Coordination, identifying research gaps and dissemination). For further information, please check http://www.pinestrength.eu/.

Fusarium circinatum, disease management, COST

KG I - 1228 (Uni Freiburg)

IUFRO17-2503 **Evaluation of soil and alternative hosts as potential inoculum sources of Fusarium circinatum in plantations of Pinus radiata**

Hernández Escribano, L.* (1); Elvira-Recuenco, M. (1); Iturritxa, E. (2); Raposo, R. (3)

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Abstract: Plantations of P. radiata are usually replanted after harvesting, so evaluating potential sources of inoculum is of particular relevance to prevent infection of trees in the new stand. Specifically, we studied (1) the presence of the fungus as an endophyte in plants growing under Pinus radiata symptomatic trees that may act as a reservoir of inoculum; and (2) survival times of F. circinatum in the pine debris and soil of plantations with pitch canker disease. Results showed the presence of Fusarium circinatum in the following species: Agrostis capillaris, Pseudarrhenatherum longifolium, Centaurea debeauxii, Teucrium scorodonia, Sonchus oleraceus, Rubus ulmifolius and Hypochaeris radicata. Regarding survival, naturally colonized branch segments and their needles were placed on soil in two locations and sampled at intervals of 4-7months during the following two years. After 858 days the pathogen was not recovered from any of the branch segments sampled at either of the two locations and only in one needle piece out of 120 analyzed. F. circinatum was not recovered from 2-mm-sieved soil collected under pitch canker-infected pines. We conclude fungus in debris or in soil is not likely to contribute to reinfection of new plantations after two years, but pathogen in alternative hosts may be present for unknown time.

pitch canker, persistence, inoculum reservoir

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IUFRO17-2494 **Impact of climatic factors in the establishment of pine pitch canker in new disease scenarios**

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Abstract: *Fusarium circinatum*, which causes pitch canker disease in *Pinus* species, is an exotic pathogen firstly reported in Spain in 2005, and in Europe only recorded at present in the Iberian Peninsula. To predict the impact this disease may have in new scenarios due to pathogen spread and climate change, we examined two main factors influencing infection process: temperature and humidity. For that, *in vitro* and *in vivo* trials were performed with three isolates from the two mating types and different geographic origin. *In vitro* trials objective was to know variation in mycelial growth and germination rate at various temperatures and time intervals. *In vivo* trials were done to know time to symptom appearance and disease progress. Pinus radiata 1-2 year old plants were inoculated with a spore suspension in the excised main stem and exposed to temperatures ranging from 5ºC to 30ºC in combination with high relative humidity periods from 6 to 48 hours. We determined the maximum and minimum temperatures close to umbral pathogen development (5 ºC and 40ºC respectively) as well as optimum temperatures (20-25 ºC). *In vivo* trials also showed that conidia or mycelium might remain in the host producing asymptomatic plants depending on temperature and humidity conditions.

F. circinatum, temperature, humidity, infection

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300 - Pine pitch canker - strategies for management of Gibberella circinata in greenhouses and forests

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IUFRO17-2329 **Effect on in planta virulence and extracellular lignocellulolytic enzyme production of Fusarium circinatum isolates infected by FcMV1 and FcMV2-2.**

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Abstract: The multicopper oxidase group of enzymes includes laccase (benzenediol: oxygen oxidoreductase, EC 1.10.3.2) which play a major role in the degradation of phenolic compounds such as lignin. They are commonly produced by fungi and have been suggested to be involved in host colonization by phytopathogenic fungi. Three putative Mitovirus spp. have been isolated from Fusarium circinatum Nirenberg & O'Donell, the causal agent of pine pitch canker disease. In this study, the effects of single and double mycoviral infections (i.e. Fusarium circinatum mitovirus 1 and 2-2) on laccase activity, in vitro growth rate and pathogenicity on Pinus radiata D. Don seedlings were investigated in seven pairs of F. circinatum monosporic cultures. Extracellular laccase activity was analyzed by the Bavendamm test, image processing and a spectrophotometric method. Mycelial growth, in vivo pathogenicity and seedlings survival probability were also determined. The findings showed that (i) mycelial growth of isolates from the same fungal population was homogeneous, (ii) the presence of mycovirus appears to increase the virulence of fungal isolates, (iii) co-infection (with two mycoviruses) caused cryptic effects in fungal isolates, and (iv) laccases embody a possible auxiliary tool in fungal infection.

Biocontrol Hipovirulence Laccase Mycovirus

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IUFRO17-1900 **Susceptibility of Scottish Scots pine to the Pine Pitch Canker Pathogen, Fusarium circinatum**

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Abstract: Fusarium circinatum, cause of pitch canker of pines, poses a threat to the eleven species of pine native to Europe, plus exotic species planted on the continent. The most naturally widespread of all pines, Pinus sylvestris is susceptible to the pathogen, but the range of variation in susceptibility of the many provenances of this species is unknown. Scots pine is the national tree of Scotland. A range of sub-provenances of P. sylvestris occur, divided geographically. In this work, the susceptibility of seven Scottish P. sylvestris sub-provenances was determined by artificial inoculations of 2-3 year old plants under controlled environmental conditions in Palencia, Spain. Inoculation resulted in resin bleeding in most plants. Variations in susceptibility to F. circinatum between the sub-provenances of P. sylvestris were found. Most plants of all sub-provenances died within 80 days of inoculation; numbers of survivors at that time were greatest in the North Central sub-provenance. Small numbers from 4 sub-provenances remained alive at 132 days after inoculation. Further work is required to determine if lower susceptibility in some plants was due to sub-provenance differences, or to overall genetic diversity in the Scottish provenance of P. sylvestris.

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IUFRO17-2575 **Susceptibility of Turkish Conifer Species to Fusarium circinatum**

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Abstract: Records of the numbers of invasive forest pathogens worldwide and the disease outbreaks caused by these damaging organisms have increased at an unprecedented rate in recent years. Amongst these pathogens, the fungus Fusarium circinatum is particularly notable as potentially a highly damaging pathogen of pines, has spread rapidly from its presumed origins in Central American high altitude pine forests to many regions of the world. Like many pitch canker disease-free countries, Turkish pine forests are also expected to be affected by it due to current and predicted future climatic suitability of pine forest. Nevertheless, nothing is known on the susceptibility of Turkish pine and/or other conifer species and provenances to this disease. The aim of the work carried out here was to test the susceptibility of some coniferous tree species and provenances during their germination and early seedling establishment against F. circinatum.

Tree species tested in this experiment were; Pinus brutia, P. nigra subsp. pallasiana, P. sylvestris, P. pinea, P. halepensis, P. radiata, Pinus pinaster, , Abies nordmanniana subsp. equi-trojani and Cupressus sempervirens. Single F. circinatum isolate with two different concentrations (103 and 106 spores ml-1) was used in the inoculation experiment and given into soil mixture. Survival analyses based on the non-parametric Kaplan-Meier estimator were carried out to determine survival probabilities of the hosts. All species were susceptible to F. circinatum at both doses concentration. Although survival analyses revealed significant differences between host species at both inoculation concentrations (X2 =105, d.f =8, P=0 and X2 =38.4, d.f =8, P<0.001, respectively), further studies are required to determine the susceptibility of older seedlings of these species to F. circinatum.

Pitch canker, Gibberella circinata, seed

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IUFRO17-3367 **Management of Fusarium circinatum in Pinus radiata plant production at the Arauco nurseries in Chile**

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Abstract: Fusarium circinatum (teleomorph Gibberella circinata) was first detected in Pinus radiata nurseries in Chile in 2001. In this environment, the fungus is well-established, and permanent effort made to manage losses have greatly reduced its negative impact. This pathogen has not been detected in plantations and there is no evidence of the pitch canker disease as it is known in radiata pine plantations in Chile and in the rest of South America countries where it has been detected. Monitoring has had focus special attention to insects that could be associated with F. circinatum, as pine shoot moth Rhyacionia buoliana and these have also not shown any association with the fungus. Population genetic studies on isolates of F. circinatum in Chile have shown that the pathogen has very low genetic diversity, suggesting limited introduction into the country. Significant efforts have been made to develop planting stock with high tolerance to F. circinatum, which should minimise damage if pitch canker become a problem in the radiata pine plantations in Chile. Sanitary management is important for the inoculum reduction, including the elimination of symptomatic plants, clean machinery and tools used in plant production, and sanitation of the hands and shoes of the workers. Fungicide programs are also implemented with a very limited number of fungicides allowed by FSC, biological control products and bioestimulants. The results of these studies illustrated the potential to reduce mortality due to F. circinatum by sanitation, inoculum reduction and improve plants quality.

Fusarium circinatum, nursery diseases

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56 - Modern approaches in evaluating ozone impacts on forests

K 2-4 (Konzerthaus Freiburg)

IUFRO17-615 **Metabolomics and transcriptomics elucidate the mechanisms behind the detoxification and defence processes against ozone stress - insights from the birch and aspen studies**

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Abstract: This presentation combines the results from several ozone experiments with birch (Betula sp.) and aspen species (Populus sp.) where metabolomic and transcriptomic methods have been used, aiming to demonstrate the potential of molecular tools to elucidate the mechanisms behind the detoxification and defence processes, as well as genotypic differences in ozone sensitivity. Long-term ozone exposure in field conditions resulted in major shift in leaf metabolite profiling in two silver birch (Betula pendula) clones. The main changes included increases in quercetin glycosides and compounds related to leaf cuticular waxes formation and decreases in compounds related to carbohydrate metabolism, some triterpenoids, as well as fatty acid and phytol derivatives. During a long-term exposure to elevated ozone and CO2 in open-top chambers (OTCs), ozone treated silver birch leaves showed up-regulation of many senescence-related genes. The combined ozone x CO2 treatment demonstrated that elevated CO2 can only temporarily or partially alleviate the negative effects of ozone, e.g. through synthesis of secondary compounds. Changes in gene expression were followed at Aspen FACE site in paper birch (Betula papyrifera): Ozone induced defensive reactions to oxidative stress and earlier leaf senescence, marked as decreased expression of photosynthesis- and carbon fixation-related genes. The results from three Euramerican poplar clones (Populus deltoides × Populus nigra), exposed in growth chambers, suggest a major remobilization of amino acids in response to ozone, in order to provide energy and antioxidative defence. Concluding from our experiments, good ozone tolerance of these species and genotypes was related to greater transcriptional response and capacity to target primary metabolism towards defensive pathways, particularly phenolic and leaf surface wax compounds, and/or biosynthesis of ascorbate and glutathione.

ozone, CO2, metabolomics, transcriptomics

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1686 **The new generation Free Air Controlled Exposure (FACE) system for exposing communities of deciduous tree species to O3 in Japan**

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Abstract: A new generation free air controlled exposure (FACE) system for exposing communities of deciduous broadleaved and coniferous trees to O3 has been established at Sapporo, Japan, in 2014. Two replicated O3 treatments (ambient and elevated) and three kinds of soil are employed in this FACE system; for elevated O3 treatment, doubled background O3 levels have been effectively achieved during the first two years of operation. This is the only FACE system in Asia for assessing O3 effects on communities of trees and the first in global employing soil condition as an additional factor. Four years have passed since its operation initiated, and some of the findings have already been published. An integrated assessment is ongoing which includes plant ecophysiology and defense mechanisms, species-specific responses, emissions of biogenic volatile organic compounds, insect ecophysiology, plants-O3-insects interactions, decomposition process. This system simulates forest succession at the early stages and the findings will contribute significantly in understanding complex interactions at community level.

brown forest, volcanic ash, ozone, serpentine

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1237 **Ontogenetic changes in grazing characteristics of leaf beetles on canopy of seedlings and young trees of Japanese white birch grown in free-air ozone enrichment systems.**

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Abstract: White birch holds an essential role in forest rehabilitation and landscape management after disturbances. Recently, severe grazing damage by mainly leaf beetle was found along roadsides and parks in a town where nitrogen oxide (NOx) levels are increasing. As NOx are considered precursors of ozone (O_3), atmospheric O_3 concentration also increases.
Most defense chemicals are originated from photosynthates. We thus hypothesized that grazing damage would be more severe under elevated O_3, where photosynthesis is suppressed. To test our hypothesis, we assessed the effect of elevated O_3 on grazing damages on white birch between seedlings and young trees with use of free-air O_3 enrichment systems (about 70 nmol/mol). Grazing trend was opposite from our hypothesis: white birch grown in elevated O_3 had lower grazing damage by leaf beetle as compared with ambient condition. Based on life cycle of leaf beetle, over-wintered adults oviposit mainly on abaxial side of leaves grown at ambient (about 35 nmol/mol) but not on leaves at elevated O_3.

However, in a choice bioassay experiment in laboratory, adult leaf beetles preferred leaves developed in elevated O_3. Defense chemicals (total phenolics and condensed tannin) of these leaves were lower than in ambient leaves. Furthermore, we examined the direct effect of O_3 on insects by a Y-shape experiment and found unaffected by elevated O_3 in behavior of leaf beetles.
Based on the above findings, we determined the emission of biological volatile organic compounds (BVOCs) to test whether BVOCs act as repellent against leaf beetle. BVOCs (mainly MT: mono-terpene, SQT: Sesquiterpene) showed no difference between elevated O_3 and ambient (MT at elevated O_3 was marginal larger). We now consider that O_3 may affect composition of BVOC and thus the behaviour of leaf beetle.

birch, free-air O3 fumigation, BVOC, leaf beetle

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56 - Modern approaches in evaluating ozone impacts on forests

K 2-4 (Konzerthaus Freiburg)

IUFRO17-587 **A mechanistic modelling approach to link ozone susceptibility to constitutive and induced defenses**

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Abstract: Currently ozone damage is calculated either from its cumulative air concentration or (more mechanistically) by the number of molecules taken up. Usually, a threshold is considered that is independent on environmental or physiological conditions. However, this threshold is actually a variable defense barrier that depends on the physiological properties and the degree plants are stressed due to other environmental factors.

Here, a model is presented that accounts for three defense barriers: stomatal conductance, a resource-requiring constitutive defense mechanism, and a species-specific option to induce further detoxification processes. The induced defenses include the production of BVOCs which are known to increase membrane stability and trigger oxidative reactions that decrease the amount of aggressive ozone in and outside the leaf.

This is the first time processes of photosynthesis, ozone damage, and BVOC emissions are linked together in a physiologically plausible way. The sensitivity of the model to other environmental stresses that lead to stomatal closure and detoxification is demonstrated and the possibility to link it into models of leaf gas exchange is discussed.

BVOCs, ozone, detoxification, model development

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1927 **Epidemiological analysis: a new approach for forest protection against ozone**

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Abstract: Epidemiology is the study of how often diseases, injury and other health-related events occur in a defined population and why. The impact of surface ozone (O3) on vegetation is under-investigated at regional scale while huge areas are exposed to high surface O3 levels and its concentrations are expected to increase in the next future. Ozone effects on vegetation depend on the air concentrations but also on the O3 uptake through the stomata (Phytotoxic Ozone Dose). The majority of previous epidemiological assessments used ambient O3 exposure as a metric of injury. Epidemiology of O3 injury may be very helpful in particular when forests are investigated, as large trees require expensive experimental facilities for realistic O3 simulation and a few individuals can be usually investigated.

A standard for forest protection is considered biologically relevant when it translates into real-world forest impacts. Therefore, epidemiological investigations where large-scale biological responses (radial growth, crown defoliation, visible foliar O3 injury) are compared with ambient data in the field provide useful information for establishing the best standards and thresholds for forest protection from O3.

Unique in the world, the LIFE project MOTTLES combines field epidemiology with plant-responses to O3. MOTTLES addresses cross-border issues with ecosystem-based approaches and an innovative follow-up system at vulnerable sites for O3 injury. With the effort of set-up permanent monitoring stations in Europe, capable to return continuous hourly O3 concentrations and environmental parameters in real time, modelling stomatal O3 flux is possible. Epidemiological analyses allow disentangling and quantifying the contributions of different predictor variables to an overall plant effect. Based on flux-effect relationships, derivation of epidemiologically-based O3 critical levels represents a considerable progress in the development of methods for quantifying O3 effects on vegetation.

Critical levels, Epidemiology, Ozone, POD

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3511 **Assessing the potential impact of ozone on native vegetation: findings from the long-term pan-European monitoring program of ICP Forests**

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Abstract: The assessment of air pollution levels and effects on European forest ecosystems is the main goal of the UNECE ICP Forests program. Currently, ground level ozone is of primary interest due to its phytotoxicity and the exceedance of critical levels over large parts of Europe.
Within ICP Forests, monitoring of ozone concentrations and effects on vegetation have been carried out since 2000 according to standardized and quality assured methods on a number of intensive monitoring (Level II) sites purposively selected throughout Europe.
Ground-level ozone concentrations have been measured from April to September by passive sampling, a method proved to be particularly useful at remote sites. Effects on vegetation have been evaluated once a year through the assessment of ozone-like visible foliar symptoms, considered one of the most specific and easily detectable indicator for ozone impact.
Overall, data collected on 170 intensive monitoring Level II sites in 20 countries for 12 years reveal a downward temporal trend for both, ozone concentrations and frequency of ozone-symptomatic species. While a decreasing south-north gradient across Europe is obvious for ozone levels, a clear spatial pattern seems to be lacking for visible symptoms.
There is a great potential of the ICP Forests long-term dataset for understanding ecosystem status and trends in response to ozone. Further analyses are being undertaken to better clarify temporal and spatial patterns and to better identify relationships among ozone, other important environmental drivers, and the response of forest ecosystems.

Ozone in forest plots; foliar injury; ozone risk

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K 2-4 (Konzerthaus Freiburg)

IUFRO17-3928 **Environmental predictors of the effects of ozone concentration and stomatal ozone flux on net ecosystem production of Norway spruce: A case study from Czech Republic**

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Abstract: Daily ozone concentration, deposition and stomatal ozone flux to young (13,5 m height) mountain spruce (Picea abies /L./ Karst) forest was measured in the Bily Kriz experimental research site (Moravian-Silesian Beskydy Mountains) using the gradient method and modelled for summer periods (2007, 2008, 2009). Net ecosystem production (NEP) was measured by the Eddy Covariance technique. The ozone exposition exceeded almost two-fold the critical level of 5000 ppb h-1 in all measured periods. The stomatal ozone uptake exceeded the critical flux level of 8 mmol m-2 suggested for the protection of Norway spruce. To test the effect of ozone on NEP we used generalized additive mixed effect modelling with ozone, radiation, humidity, temperature and transpiration based on sap flow measurements as the predictors. Only hourly data between 6 and 18 hours were used, because that was when NEP production was high enough and the possible effect of ozone on it could be tested. All these predictors were tested as degree 2 polynomials and interactions of the first order, time (hours 6 - 18) was modelled as a smoother. Two separate models were constructed, one with ozone concentrations and one with ozone stomatal flux. Both models explained the same amount of variability in the NEP data (R-sq. (adj) = 0.93). The most important predictor of NEP was radiation, but the other predictors were also significant and included in the models. Due to significant interaction of ozone concentration or stomatal flux with some environmental factors (e.g. humidity), the negative effect of ozone varied depending on their values.
NEP values for test dataset predicted by the both models were on average less than 1 kg C ha-1 h-1 less than the measured values. During all three growing periods ozone concentration and stomatal uptake of ozone significantly decreased NEP of young Norway spruce trees in dependence on combination of important environmental factors.

Ozone, Net ecosystem production, Norway spruce

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59 - Responses to the increasing threat of insect pests to sustainable plantation forestry

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1572 **Pathways approaches inform early-detection strategies to slow pests invasion to planted forests**

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Abstract: International trade and the movement of people are the main causes of introductions of new insect pests and pathogens into planted forests worldwide. Preventing future invasions or minimising their impacts are highly reliant on our understanding of the respective roles of different invasion pathways. Which pathways are commonly associated with successful, high-impact invaders? Can we estimate the levels of propagule pressure associated with these? How does propagule pressure relate to the probability of a pest permanently establishing in a new area?

We will explore these questions by using New Zealand's current approach to forest health surveillance which is based on the spatially-explicit consideration of high-risk pathways. New probabilistic models (Bayesian networks) have been developed to address the risk of unintentional introduction of pests and diseases associated with seven import pathways (sea vessels, used vehicles, used machinery, sea containers, wood packaging, wooden furniture, live plants), the movement of persons (returning residents and visitors) and wind currents (natural introduction). The model estimates propagule pressure associated with each pathway, not only at the entry points (sea and airports) but also at each of 1912 "area units" covering any location in New Zealand. An optimisation model then estimates what allocation of surveillance effort (type and intensity of survey within each area unit) maximises the overall probability of detection for any defined budget.

The new system indicates that the probability of early establishment of new forest pests and diseases is particularly high around pathway-specific facilities such as ports, car yards or container cleaning depots. These facilities are also well correlated with populated areas, showing that all forests may benefit from the allocation of surveillance effort in the highest risk urban and peri-urban environments.

forest health, surveillance, propagule pressure

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1290 **Early detection of alien wood-boring beetles in southern Europe: from the arrival to the forests**

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Abstract: International ports are generally considered the most likely points of entry for alien wood-boring beetles. A better understanding of the factors affecting the arrival and establishment of these pests is of utmost importance to improve the efficacy and the cost-effectiveness of early detection. Our work aimed first at finding the most effective survey protocols to be used in early-detection programs, and second at understanding how the port size and the characteristics of the surrounding landscape (forest cover and forest composition,), may influence the occurrence and spread of alien wood-boring beetles from the point-of-entry to the surrounding natural forests. For three consecutive years (2012-2014), the most important Italian international ports, the surrounding forests (located 3-5 km away) and high-risk introduction sites (wood waste landfills) were monitored from May to September with different types of traps baited with multi-lure blends. Both alien and native Scolytinae, Cerambycidae and Buprestidae beetles were then identified. The main results suggest that the simultaneous use of traps both in ports and in their surrounding broadleaf forests can strongly increase the probability of alien wood-boring beetle interceptions. The identification of sites where the arrival and establishment of alien species is more probable (large international ports surrounded by broadleaf forests), combined with an efficient trapping protocol (multi-funnel traps baited with multi-lure blends), can substantially improve the efficacy of early detection. Similar approaches may be used in many countries as early warning systems implemented at the European scale.

Alien pests, early warning systems, survey

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-128 **The Use of Semiochemicals for Monitoring and Management**

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Abstract: The probability of capturing a species in a semiochemical-baited trap is a function of the active space of the trap (i.e., the distance from the trap that individuals initiate directed orientation toward it) and the proportion of insects attracted that are captured. Considerable effort has been invested in attempting to improve the sensitivity of traps by identifying and synthesizing attractants. Although empirical evidence is largely absent, it is generally assumed that differences trap active space contribute to differences in captures among intercept traps baited with different semiochemicals. Unfortunately our ability to increase trap captures by increasing trap active space is limited by meteorological and behavioral factors. Our ability to optimize the proportion of insects attracted that are captured is limited by the fact that in no instance do we possess a mechanistic understanding of why trap capture varies among different trap design factors. Field trapping studies using pheromone-baited intercept trap designs were conducted to characterize the impact of different trap design factors on the capture of pine sawyers (Monochamus spp., Coleoptera: Cerambycidae). Subsequently, the plume structure of these intercept trap designs was characterized using CO2 as a surrogate odorant for pheromone. The field trapping studies demonstrated that trap captures of pine sawyers varied significantly with intercept trap design and the plume structure analyses documented significant differences in CO2 plume structures that may explain the observed differences in trap capture.

intercept trap, behavior, plume structure

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59 - Responses to the increasing threat of insect pests to sustainable plantation forestry

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1453 **Biological control of insect pests in non-native forest plantations: opportunities and constrains**

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Abstract: Eucalypts and Pines represent key forest plantations globally, whereas in great part of their area they are planted as non-native species. Health problems in non-native forest plantations steeply increased in time following invasions of insect pests and pathogens. These hazards have become a major concern for the forestry sector. Classical biological control by the use of natural enemies from the native range of the invasive pest, which were either intentionally or accidentally introduced, seems to play a major role in restraining these pests. Still, along some major successes, several difficulties may hinder solution for quite a few unsolved problematic cases and invasive pests in the future. One major obstacle relates to the underfunding of research and development programs supporting biological control. There is still concern about the potential negative role of the introduced new biological control agents by government agencies and environmental organizations on potential economic and ecological risks. And, in some cases finding or selecting efficient natural enemies is still a major challenge. A revision is made on biological control programmes for Eucalyptus and Pinus pests', comparing success rates, ecological and economic impacts with respect to the different groups of the insect pests and their role in their native area. An emphasis will be placed, as a study case, on the biologicol control of the Eucalyptus snout weevil Gonipterus platensis in Southwestern Europe. We will also discuss the need for higher investments in biological control and whether the ecological constrains that may be posed by the introduced biological control agents are justified. The further need of scientific cooperation between countries will also be discussed.

Biological control, planted forest, non-native

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1028 **Eucalyptus insect pests and their management in China**

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Abstract: According to the investigation and reports, over 400 species of insects belonging to 10 orders and 81 families feed on *Eucalyptus* in China, but only 53 species were found in 1980. Of these, just a few species can be identified as invasive. Some indigenous insects having the feeding preference on *Eucalyptus* became the *Eucalyptus* pests at the soonest; Several endemic omnivore eruptive pests had switched to the new host and developed into major *Eucalyptus* pests in comparatively early time; More and more latent crop pests have been evolving into regular *Eucalyptus* pests gradually. Most seriously, species without damage record, even rarely encountered in local ecosystems, have also been evolving into regular *Eucalyptus* pests. This situation leads to emerging of more harmful species and bigger populations of endemic pests in forest ecosystems, and may increase damages to native crops and wild trees or shrubs.
Due to the intensive cultivation of *Eucalyptus*,chemical and biological control methods are essential to prevent pest outbreaks. The fungal agents like *Beauveria bassiana* and bacterial agents like *Bacillus thuringiensis* are applied against a range of defoliators, BsNPV product on *Buzura suppressaria* is on trial, while sometimes the chemicals must be used to depress big pest populations. The termite damage on young plantations is controlled by delivering chemical repellents into seedling cup before plantation. The severe damage of the invasive *Leptocybe invasa* has been prevented by obsoleting susceptible clones, while these clones are normally fine or resistant to other diseases. The invasive psyllid *Blastopsylla barbara* is commonly occurring, and interacts with fungal diseases, chemicals to control the pest and major diseases were selected, but spraying in field is a big difficulty and of poor effect. Now managers recognize silvicultural practice can be effective but these methods must be based on sound science and practically acceptable.

Eucalyptus, insect pests, management, china

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3076 **A multi-omics approach to understand molecular mechanisms of host resistance in Eucalyptus grandis against the gall wasp, Leptocybe invasa**

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Abstract: Leptocybe invasa is an economically important insect pest on Eucalyptus plantations, inducing galls and causing stunting in seedlings. In order to gain insight into host resistance mechanisms against the pest, we conducted a Genome Wide Association Study (GWAS) in a breeding population of Eucalyptus grandis. Eighteen month old trees were scored as 0 for not infested, 1 for infested without galls, 2 for infested with galls and 3 for infested with lethal gall formation. We genotyped 563 insect challenged E. grandis individuals from 61 half-sibling families using the EucHIP60K.Br SNP array and identified 15,445 informative markers for GWAS analysis. A Multi-Locus Mixed Model (MLMM) approach was used to find single nucleotide polymorphism (SNP) markers associated with resistance to L. invasa. Seven genomic regions were identified from a total of 31 SNP markers with significant single marker associations for L. invasa ($P < 0.05$) on chromosomes 3, 4, 5, 7, 8 and 9. We complemented the GWAS with transcriptomics in resistant and susceptible genotypes to identify candidate genes associated with resistance. We additionally explored the secondary metabolite profiles in resistant and susceptible genotypes and observed the induction of different mono- and sesquiterpenes in the two genotypes. Taken together, the 'omics approaches have revealed defence mechanisms and molecular markers that will contribute to enhanced resistance against L. invasa in future.

GWAS, transcriptomics, terpenes

All Division 7 (Forest Health) Meeting

59 - Responses to the increasing threat of insect pests to sustainable plantation forestry

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-961 **BiCEP: Building collaboration to advance biological control**

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Abstract: Australian-origin pests of eucalypts have been moving around the world since 1873. Under historical scenarios (a steady linear increase in the numbers of pests invading, with slow subsequent movement between countries and continents), traditional approaches to classical biological control, where individual countries or regions funded natural enemy searches and carried out the required specificity testing and released the agents, were effective. However, since the 1990's, the invasion of new eucalypt pests has increased almost exponentially with rapid subsequent invasion of these pests into new countries and across continents. This is driving new approaches to developing biological control programs, with individual countries (particularly those in the developing world) less able to cope with multiple new pests arriving in rapid succession. A more collaborative and coordinated approach to biological control is required, where funds and expertise can be cost-efficiently pooled and shared to develop effective biological control for eucalypt pests. A framework has now been developed by industry and researchers worldwide to attempt to solve this problem through the formation of the Biological Control of Insect Pests Alliance (BiCEP). The Alliance carries out collaborative research in Australia and overseas on biological control of the key invasive pests prioritised by its industry partners. Approaches used in this collaboration include conventional surveys for endemic natural enemies in Australia, genetic characterisation of these agents and climate matching with invaded countries. Practical outcomes from current and ongoing research, and future directions and improvements to managing biological control of eucalypt pests into the future will be presented.

Biological Control, Eucalypts, Collaboration

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3320 **Predicting the impact of processionary moth defoliation on pine plantation production over a full timber rotation**

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Abstract: Planted forests are under growing risk from insect damage due to the changing climate that drives more frequent outbreaks and increases stand vulnerability. For such forests to continue providing biomass resources that society demands, it will be necessary to adapt forest management in order to increase their resistance. While short term effects of insect defoliation on tree growth are well known, we are lacking empirical data to estimate the impact of recurrent outbreaks on yield over a full timber rotation. To circumvent this problem we complemented an empirical tree growth model with a risk sub-model. This sub-model was based on equations accounting for insect demographic fluctuations at the regional then stand scales, tree probability of infestation, intensity of tree defoliation and resulting radial growth loss. The model was developed for maritime pine stands experiencing cyclic defoliations by the pine processionary moth. Then we ran simulations to investigate changes of the rotation lengths and thinning regimes of stands. We found that particular combinations of thinning frequency and intensity could result in negligible effects of defoliation on production loss. This demonstrates that empirical models represent suitable tools for adapting plantation forestry practices to increasing biotic threats.

Thaumetopoea, Pinus, growth model, silviculture

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2069 **Gall-forming wasps threaten non-native plantation-grown Eucalyptus**

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Abstract: Species of *Eucalyptus* are amongst the most successful trees introduced into new environments to establish plantation forestry worldwide. The popularity of these trees is due to their rapid growth, suitability to diverse environments and numerous commercial applications. The productivity of *Eucalyptus* plantations has, however, been challenged by the recent increase in invasive pests. This has been driven by increasing global travel and trade, especially the importation of live plants and plant material. The increasing numbers of accidental introductions also include gall-forming wasps. In this review, we consider global patterns of introduction and spread of gall-forming wasps on *Eucalyptus*, as well as available tools for their identification, and options for short and long-term management. These wasps adversely affect the growth of infested trees and in extreme cases can stunt their growth or cause defoliation. Many of these introduced species lack taxonomic descriptions, and detailed information regarding their biology is sparse or unknown. The small number of taxonomists able to identify these insects further delays accurate diagnoses and consequently initiation of management strategies. Even when initial identifications have been made, these are frustrated by the existence of morphologically similar, but distinct cryptic species. Accurate identification is the first step to manage these invasive species. This is because management through breeding or biological control may not be effective against distinct species.

invasive species, plant galls, plantation forestry

All Division 7 (Forest Health) Meeting

71 - Early detection and monitoring of invasive forest pests and pathogens with citizen science

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3406 **Citizen science initiatives: opportunities to manage global invasive forest pest challenges**

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Abstract: Invasive species introductions in forests are increasing and global mitigation strategies are needed. Here we consider several global issues for invasive species management (e.g. limited resources, unknown species and origins, consumer driven pathways, single country strategies, etc.) and suggest citizen science as a useful tool to counter these issues. We highlight projects that fit within each of the invasive species management options (prevention, early response, containment, and mitigation), and we identify the benefits that these projects provide to enable important research to mitigate invasive species impacts. Such projects have demonstrated that observations from citizen scientists contribute to the early detection of invasive pests at local scales and sample submissions increase predictive capacities to model hotspots of invasion at regional scales. Given the success of citizen science programs at these scales, and the need for global action to alleviate the effects of invasive species, we recommend the implementation of a global citizen science invasive pest-monitoring program, with specific resources and training provisions for emerging and developing economies. Such a program would alleviate forest pest invasions by countering several management issues through increased awareness, a global network of observers, and coordinated borderless research.

citizen science, invasive species, forest health

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IUFRO17-597 **Oregon Forest Pest Detectors: Oregon's first defense against invasive forest pests**

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Abstract: The emerald ash borer (Agrilus planipennis) and Asian longhorned beetle (Anoplophora glabripennis) are not currently established in Oregon, but upon arrival could cause significant negative environmental and economic impacts. The Oregon Forest Pest Detector program trains natural resource professionals and volunteers to identify and report these high-priority, federally-regulated, invasive forest pests in the United States, thus increasing the chance of early detection and rapid response. The hybrid format of the course includes a self-paced online course and a face-to-face field workshop. The online course provides a background on invasive species, pest identification, and how to file a report. The field workshop features a course of host trees with mock signs and symptoms for each insect that participants must decipher and subsequently decide whether to file a report. Since the program began in spring of 2015, we have trained 272 detectors throughout the range of vulnerable host species. 73% of participants report complete confidence in their ability to recognize and report EAB and ALB signs and symptoms after the training. We have also incorporated new pests as they approach or arrive in Oregon, such as the Asian gypsy moth (Lymantria dispar asiatica), with short, optional field sessions for program graduates.

invasive insects, early detection, citizen science

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IUFRO17-620 **When policy meets science and public engagement: designing and building a tree health citizen science survey in the UK**

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Abstract: There is an urgent need for observations to monitor tree health. Citizen science has been identified as a useful approach to expand the number of people monitoring and observing trees, gain more information at a local level, and raise public awareness of tree health issues. Since the publication of the Tree Health and Plant Biosecurity Action Plan in the UK in 2011, public and stakeholder engagement and citizen science have become increasingly prominent as a potential response to the challenges of increased surveillance.

In this presentation, I draw on findings from a social science research project on 'harnessing enthusiasm' for citizen science and tree health, that launched only weeks before the reporting of the first identification of Chalara dieback of ash in the UK in 2012. This event added a sense of urgency to the development of tree health citizen science projects in the UK, and the need for social research to examine what happened next. I share findings from one of my case studies, specifically the 'design and build' phase of the OPAL (Open Air Laboratories) Tree Health Survey that launched in May 2012. Here policy actors met with forest scientists and public engagement specialists for the first time to develop a citizen science survey that would raise awareness of tree health issues, improve the public's identification skills, and offer insights into the absence/presence of tree pests and diseases. I reveal the ways in which the survey team: (1) negotiated competing expectations around policy, science and public engagement objectives; (2) addressed assumptions about public interest in trees and observational ability; and (3) grappled with communicating the complexities of pests and diseases in a citizen science survey. In the conclusion, I offer some important lessons for policy, science and public engagement communities faced with the challenge of developing citizen science surveys in an emerging crisis.

citizen science, tree health, enthusiasm, policy

All Division 7 (Forest Health) Meeting

71 - Early detection and monitoring of invasive forest pests and pathogens with citizen science

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IUFRO17-3250 **Citizen science helps predict spread of emerging infectious diseases**

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Abstract: Engaging citizen scientists is becoming an increasingly popular technique for collecting large amounts of ecological data while also creating an avenue for outreach and public support for research. Here we describe a unique ongoing citizen science project, in which for almost ten years citizen played a key role in the geographic assessment of an emerging infectious disease. The yearly citizen-science program called "Sudden Oak Death (SOD) Blitz" engages and educates volunteers in detecting the causal pathogen during peak windows of seasonal disease expression. SOD blitzes are designed as grassroot activities: participants are trained to survey and sample for SOD by scientists in meetings organized by local environmentalists, but are free to sample wherever they wish. SOD distribution data are regarded as public and shared with the public through the media, the internet, and through an ad hoc App called SODmap mobile. Each year, 4-500 participants survey over 20.000 trees, and sample approximately 2000 of them. All samples are processed at UC Berkeley scientists who also release the data. In 2011 alone, it was estimated over one million people accessed the data. When SOD Blitz data were used to develop predictive maps of disease risk, such maps were as informative and accurate as those developed using data collected by scientists. Our results indicate that using long-term citizen-science data to predict the risk of emerging infectious plant diseases in urban ecosystems holds substantial promise.

technology transfer, invasive diseases,

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IUFRO17-1519 **Co-development of a cross-sector nationwide passive surveillance tool for the primary industries and general public of New Zealand**

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(1) Scion (NZ Forest Research Institute), Christchurch, New Zealand; (2) Lincoln University, Lincoln, New Zealand

Abstract: New Zealand has embarked on an ambitious project to co-develop a web and smart phone based communication network that allows participants to record biosecurity threats to New Zealand. The final platform will make use of NatureWatch NZ and will allow users to participate in both the recording of observations and their identification. Participants from central and regional government agencies will join Maori groups and the forestry, kiwifruit, pipfruit, avocado, wine, dairy, beef and lamb sectors. We will report on the co-development process used to build a consensus of the functionality required to meet the shared needs of all participants. We will present the proposed functionality and provide an outline of planned case studies for implementation of the tool in early 2018. Finally we will explore the concept of community-based social marketing (CBSM) approaches to overcome behavioural barriers to participation in biosecurity facilitation in workplace situations and by the general public.

passive surveillance; invasive species; detection

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IUFRO17-2374 **Empowering volunteers in early detection and management of forest invasive species using 3D printed models, online tracking systems and UAVs**

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Abstract: Early detection, rapid response, citizen science, volunteer engagement and agency collaboration are the major tenets of the University of Minnesota (UMN) Extension Forestry's efforts to manage invasive species. Testing and adopting new technologies is necessary to improve methods. UMN Extension is working with state agencies, Conservation Corps of Minnesota crew members, volunteers and other active woodland managers to adopt an online, cloud-based mobile Invasive Species Management Tracking (ISMTrack) system that can collect and share invasive species management information from the field and across agencies and users. Building on progressive Extension Forestry programs that engage volunteers in early detection, rapid response and volunteer-led invasive species management we are now using 3D printing to create invasive species models and testing UAVs (unmanned aerial vehicles). 3D printing is used to develop invasive species models for volunteers to practice identification skills for emerging invasives. UAVs are being tested for their accuracy and efficiency at detecting an invasive woody vine in the tree canopy. UMN Extension has also developed a new calculation to evaluate the public value of highly trained volunteer managers. Using this new approach, Invasive Blitz volunteer leaders generated $3.3 million USD in management value over 4 years; a return on investment of 1:428. Extension is a leader in education, outreach, citizen science and volunteer management, but program partnerships with the MN Department of Agriculture, MN Department of Natural Resources and MN Department of Transportation are key to successful program innovation and overall success in managing invasive species.

invasives; 3D-print models; online database, UAV

All Division 7 (Forest Health) Meeting

71 - Early detection and monitoring of invasive forest pests and pathogens with citizen science

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1434 **Observatree: A pioneering and award winning Tree Health Early Warning System combining Citizen Science with plant health professionals**

Crow, P.* (1)

(1) Forest Research, Alice Holt Lodge, Surrey, United Kingdom

Abstract: The Observatree project empowers over 230 volunteers to report findings of tree pests and diseases to inform their existing distributions and help identify early outbreaks. Observatree volunteers are trained to identify 21 priority pests and diseases and they are supported by high quality, scientifically-based learning materials which are used by tree health professionals and researchers across the UK and internationally.
Thousands of records have been submitted by the volunteers and hundreds of priority pest and disease incidents identified. Our volunteers also record the absence of pests and diseases, providing valuable background data and potentially identifying geographic regions where pests or diseases are unable to become established. Members of the public also submit online tree health reports and where these lack sufficient information for diagnosis, our volunteers can contact the reporter and help them to complete the report. This helps our professional diagnosticians by providing them with the quality of data they need.
Following the multi-agency approach to an outbreak event in 2015, Observatree formed part of the team that won the 'Data Pioneer' category in the Defra Team awards for that year. Observatree is a successful multi-partner project, led by Forest Research and 50% funded by the EU LIFE programme.

Citizen Science, Tree Health, Volunteers, Training

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-2402 **Stream monitoring for Phytophthora in Washington State, USA: A citizen science project**

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Abstract: *Phytophthora ramorum* (Oomycetes), an invasive plant pathogen of regulatory concern, has raised awareness of the interconnections between nurseries and wildland forests and the significance of the nursery plant pathway for the movement and establishment of plant diseases in the USA. This project was initiated to monitor for early detection of *P. ramorum* in western Washington streams and ponds. Volunteers from the community collected bait samples in surveys conducted in 2010-2015 and assisted with sample processing in the lab. Since *P. ramorum*, has been found in only a few WA streams, this survey also provides baseline information on other oomycetes present in urban, rural, and wildland areas. Another goal is to identify *Phytophthoras* moving from urban landscaping into stormwater retention ponds. These ponds may serve as sentinel sites for the detection of exotic *Phytophthoras* that are introduced via the movement of diseased nursery stock.
Local high school and college students gained experience doing scientific research that they can use in future study, as well as adding to their resume. In this project we interacted with volunteer organizations, landowners, and the general public. As a result, awareness of waterborne plant pathogens and the importance of sanitation to prevent their movement was increased.

Early detection, hands-on research, education

All Division 7 (Forest Health) Meeting

Pine wilt disease: progress in understanding the dynamics and developing control measures

K9 (Konzerthaus Freiburg)

IUFRO17-1004 **Xylem dysfunction in pine trees suffered from pine wilt disease**

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Abstract: Pine wilt disease caused by pinewood nematode is characterized by a rapid wilting of pine tree due to water deficit evaluated by measuring xylem pressure potential of needles. Water deficit is seemed to be due to the lowering and finally cessation of xylem hydraulic conductance. I would like to review the water relations including some new findings on xylem cavitation in the diseased pine.
Moisture profile of pine stem detected by MRI imaging and X-ray showed visibly the decreasing and disappearance of hydraulic area of xylem in diseased pines. Quantitative measurements of the hydraulic conductance of xylem and the sap flow also showed the cessation of hydraulic conductivity of xylem in diseased pines. The dysfunction of xylem in the diseased pine is thought to cause the xylem cavitation. The detection of acoustic emission, which showing an occurrence of cavitation in xylem, in a pine tree indicated an occurrence of xylem cavitation in diseased pine. Although the acoustic emission was able to detect in a healthy pine, there was difference in a number of acoustic emission events between the healthy pine and the diseased pine. A number of acoustic emission events at the given xylem pressure potential in the diseased pine were reasonably large in comparison with the healthy pine. Namely, the diseased pine was more vulnerable to xylem cavitation than the healthy pine and cavitated tracheids were not refilled again. In diseased pine, cavitation rapidly occurred in a large number of tracheids leading to a catastrophic destruction of the water conduction pathway. These findings support the idea of "runaway embolism" having a major role of the mechanism of induction of pine wilt disease.

water status, pine wood nematode, xylem cavitation

K9 (Konzerthaus Freiburg)

IUFRO17-3415 **Transcriptome Analysis and Identification of Differential Gene Expression to Response of Pine Wilt Disease in Pinus densiflora**

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(1) National Institute of Forest Science, Suwon, Korea, Republic of (South Korea)

Abstract: *Pinus densiflora* is broadly cultivated in Asia for timber, pulpwood, garden, and paper markets. However, it is suffering the severe damage due to pinewood nematode, recently. Pine wilt disease, caused by the pinewood nematode, damages and kills pine trees and is causing serious economic damage in Asia. Although the ecological mechanism of infestation is well described, the plant's molecular response to the pathogen is not well known. In order to know molecular defense mechanism of pine tree, we performed RNA sequencing to identify transcriptional changes in infected pine trees because next generation sequencing could provide the valuable information in spite of the lack of the genome sequence and an efficient approach for detecting the expression of genes in non-model organisms. We hereby reported the high throughput comparative sequence analysis of infested and non-infested stems of *P. densiflora*. In this study, over 300 million cleaned reads from *P. densiflora* mRNA were produced using Illumina NextSeq500 sequencing system. They were *de novo* assembled by 97,416 unigenes with a N50 length of 1,229 bp. Finally, our results such as differential expressed genes and gene expression patterns would provide a valuable resource for diagnosis of pine wilt disease even early stage to rescue *P. densiflora*.

Pinus densiflora, Transcriptome analysis, PWD

K9 (Konzerthaus Freiburg)

IUFRO17-2585 **Unraveling the pinewood nematode pathogenicity: Bursaphelenchus xylophilus and B. mucronatus secretome differences**

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Abstract: The pinewood nematode, *Bursaphelenchus xylophilus*, is the causal agent of the pine wilt disease (PWD) and represents an increasing threat to European conifers forest. In contrast, *B. mucronatus*, with similar morphological and ecological characteristics, differs from *B. xylophilus* on its pathogenicity to pine trees, making this nematode a good candidate for comparative analyses. Secretome profiles of *B. xylophilus* and *B. mucronatus* were obtained and proteomic differences assessed using a quantitative SWATH-MS approach. This proteomic comparative and quantitative analysis allowed the identification of proteins detected in different levels in each secretome, reflecting diverse responses of these nematodes when stimulated by a pine tree extract. While increased proteins in *B. xylophilus* secretome revealed a strong enrichment in proteins with peptidase activity and also on glycoside hydrolases and peptidase inhibitors, the increased proteins in *B. mucronatus* were mainly related to oxidative stress responses. Further studies on identified proteins were performed, namely, sequence analyses, measurement of the differential transcription levels, detection of the spatial localisation of transcripts by *in situ* hybridisation and gene silencing by RNA interference (RNAi). Proteins related to *B. xylophilus* pathogenicity and with potential to be considered as targets for nematode detection/control were selected for development of new control strategies of this important forest pest.

pathogenicity, peptidases, PWN, secreted proteins

All Division 7 (Forest Health) Meeting

Pine wilt disease: progress in understanding the dynamics and developing control measures

K9 (Konzerthaus Freiburg)

IUFRO17-1746 **Volatiles from different Cerambycidae beetles that colonize pine wilt Pinus pinaster trees in Portugal**

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Abstract: In Portugal 21 species of the order Coleoptera and Hymenoptera develop on pinewood nematode (Bursaphelenchus xylophilus) infected trees. Several common species belong to the Cerambycidae family such as Monochamus galloprovincialis, the only insect vector in Portugal. As a part of a larger project that intends to understand the role of the vector insect volatiles on the attraction of the nematode and on the pine wilt disease (PWD) system, the volatiles from Arhopalus syriacus, Monochamus galloprovincialis and Pogonocherus perroudi, removed from infected maritime pine trees (Pinus pinaster), were evaluated in different stages of the insect's development.
Insects were maintained in darkness, at 20 °C, in either disposable Petri Dishes or in clear vials, closed with a screw top solid cap with polytetrafluoroethylene (PTFE) liner.
Volatile compounds were isolated either by hydrodistillation, by organic solvent (ethanol and pentane) or by solid phase micro extraction (SPME), and analyzed by Gas Chromatography-Mass Spectrometry (GC-MS) for volatiles identification and by Gas Chromatography (GC), for their quantification.
Considering the different extraction procedures used for each species, they showed a qualitatively similar volatiles pattern, despite major quantitative differences. However each species showed a particular volatiles profile that may be the clue for the vector identification's by the nematode.

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PWD, Cerambycidae, Volatiles, Gas Chromatography.

K9 (Konzerthaus Freiburg)

IUFRO17-1761 **Advances in the Galician Pinus pinaster breeding program against the pinewood nematode (Bursaphelenchus xylophilus)**

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Abstract: Pine wilt disease, caused by the nematode Bursaphelenchus xylophilus (PWN), is a major threat for the whole Europe since its entrance in Portugal in 1999 and in Spain in 2008. Only for Spain, forecasted losses are higher than 11 billion euros for 2008-2030. One possible measure to fight against this disease is to develop a genetic breeding program for tolerance to pinewood nematode. With this purpose, a new breeding program was started in Galicia (Spain) in 2013. We performed several inoculation assays with different genetic material (species, provenances and families) under greenhouse conditions in order to search for tolerant genetic material which could be used in reforestations in case the pine wilt disease spread dramatically as it is expected. We found differences both, among Pinus species and P. pinaster provenances. Moreover, we obtained satisfactory results in the studies carried out with the Galician P. pinaster provenance, since PWN tolerance seems to be a heritable trait, so a P. pinaster genetic breeding program against pinewood nematode can be developed.

Genetic control, tolerance, pine wilt disease

K9 (Konzerthaus Freiburg)

IUFRO17-3207 **Naphthoquinones: potential bionematicides for pinewood nematode eradication from wood**

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Abstract: Naphthoquinones (NTQ), an important class of quinones and a group of reactive phenolic compounds, are widespread in nature and are considered cytotoxic with significant antibacterial, antifungal, antiviral, insecticidal, herbicidal and nematicidal properties. Environmental-friendly strategies for the pinewood nematode (PWN), Bursaphelenchus xylophilus, control are nowadays a primary concern and phytochemicals based products can be used as nematicides themselves or can serve as model-compounds for the development of new eco-friendly formulations with enhanced activity. The main objective of this study was to assess the nematicidal activity of three NTQ (1,4-naphthoquinone, juglone and plumbagin) on PWN. Twenty dispersal third juvenile stages (JIII) and 20 adults from infected Pinus pinaster were placed in 1 mL of NTQ concentrations (150, 250 and 500 ppm) and mortality monitored during 48 h. Each treatment consisted of five replicates and tap water and Triton X-100 5000 ppm as controls. The JIII mortality (100%) was achieved at 500 ppm after 12 h with 1,4-naphthoquinone and plumbagin and, after 24 h with juglone. Adult mortality (100%) was achieved at 250 and 500 ppm with the three NTQ. In order to assess the efficiency of NTQ for PWN eradication, in vivo bioassays are being carried out with naturally infected P. pinaster wood sections. Sections are dipped on different NTQ solutions and dried at room temperature for different time periods. Additionally, a vacuum-pressure-vacuum system will be explored for the NTQ wood impregnation. The potential use of these bionematicides on the treatment of infected wood will be considered.

bionematicide, impregnation, naphthoquinones, wood

All Division 7 (Forest Health) Meeting

Pine wilt disease: progress in understanding the dynamics and developing control measures

K9 (Konzerthaus Freiburg)

IUFRO17-1846 **Are there any breaks to the dispersal of the Pine Wood Nematode across Europe ? A phylogeographic study of its vector, Monochamus galloprovincialis (Coleoptera, Cerambycidae).**

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Abstract: Monochamus galloprovincialis is the main factor involved in the natural spread of the Pine Wood Nematode (PWN) in Europe, a serious pest for pine forests. Since its introduction in Portugal, the PWN has rapidly expanded its range to a large part of the country and will probably continue to expand its distribution northward Europe, especially in the context of climate change. Geographical barriers such as the Pyrénées mountain and host availability constitute two main factors shaping the dispersal pattern of the vector.
We used highly polymorphic molecular markers to disentangle historical and contemporary events leading to the current genetic distribution of 45 populations of M. galloprovincialis throughout its European range.
The distribution of genetic clusters consisted in five major geographical regions showing a strong historical footprint linked to the last quaternary glaciations. Conversely, pine host species did not appeared to play a major role in shaping genetic structure of this oligophagous species.
From an applied perspective, this study provides valuable diagnostic tools for tracing long distance movements of the PWN vector, including an accurate molecular assignation of populations intercepted at different point entries at risk in Europe.

Phylogeography, microsatellite, pine-host, PWN

K9 (Konzerthaus Freiburg)

IUFRO17-691 **The role of latent carrier tree : A small field experiment brought about informative results**

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Abstract: Although enormous time and efforts have been dedicated, Pine Wilt Disease have not yet been controlled. Aerial spray of insecticide targeting Monochamus vectors, and elimination of dead pine trees from forests are major control procedures applied in such countries invaded by Pine Wilt Disease. After intensive control programs are applied, pine wilt often recur in the same pine stand and thereby not only nullify the previous control efforts but also accelerate expansion of this disease. I suppose latent carrier tree must play an important role in recurrence of Pine Wilt Disease in the same stand after intensive control. To examine this idea we carried out small field experiment and obtained better results than expected. The results show that there are considerable number of latent carrier trees in the pine stand where pine wilt has been rampant, and trunk injection of nematicide may kill nematodes or suppress nematode propagation in such latent carrier tree, and thereby prevent disease development and expansion.

latent carrier, PWD, injection of nematicide,

K9 (Konzerthaus Freiburg)

IUFRO17-3155 **Fifteen years monitoring in Norway without finding Bursaphelenchus xylophilus.**

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Abstract: Pinewood nematode (PWN) Bursaphelenchus xylophilus has been monitored in Norwegian forests since year 2000. Monitoring was made in 10 circular areas with 50 km radius centered in points of exposure to risk material. Samples were collected in 2-3 years old logging sites, with the priority on logging waste attacked by pine sawyers Monochamus spp. An electric drill was used to collect 300 ml wood shavings, which were brought to the laboratory and incubated at +25 oC for two weeks before extraction by the Baermann funnel. In the period 2000-2015 6456 samples were obtained, 5637 from pine (Pinus sylvestris) and 802 from spruce (Picea abies). The annual sampling volume varied between 214 and 637 samples. Most samples were collected in the county of Østfold, followed by Hedmark, Buskerud, Telemark and Aust-Agder. PWN was not detected, but closely related species were present in 56 samples. B. mucronatus kolymensis was the most frequent, while B. macromucronatus was less common. Most finds of B. mucronatus kolymensis was from Hedmark (31), followed by Østfold (12), Aust-Agder (8) and Møre og Romsdal (1). Due to an assumed very low and indeed hypothetical frequency of PWN in Norway monitoring needs to continue to confirm freedom from PWN.

Pinewood nematode, monitoring, forests, Norway

All Division 7 (Forest Health) Meeting

Pine wilt disease: progress in understanding the dynamics and developing control measures

K9 (Konzerthaus Freiburg)

IUFRO17-1065 **Pine Wood Nematode (PWN) and Pine Wilt Disease (PWD) - new recommendations for control actions and forest management.**

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Abstract: Between November 2014 and October 2015 a task force set up by the European Commission discussed the best ways to control the PWN in Portugal and adjacent parts of Spain. The official report of the task force can be downloaded at:

https://ec.europa.eu/food/sites/food/files/plant/docs/ph_biosec_legis_em-measures_pwn-task-force_en.pdf

The task force concluded that some of the actions prescribed in Decision 2012/535/EU probably are not effective, or in some situations could even be counterproductive. One example is the sampling of asymptomatic trees. Since 1999 no PWN has been found in an asymptomatic pine in Portugal. Another example is the creation of large clear-cut zones around positive trees in areas where no latency of PWD is to be expected. This will only push the vector to keep on flying till it reaches the next pine. The EU Decision is under revision and a new version is expected to be in place in the first half of 2017. The main changes will be explained in the presentation.

PWN can live in many different coniferous tree species in Europe, with various sensitivity to PWD. The sensitivity for developing PWD also varies within the same tree species with different climatic conditions. PWN can be transmitted by several species of longhorn beetles of the genus Monochamus, each with its own preference for tree species and parts of the tree for nutrition feeding and for oviposition.

There is a great need for tailor-suited pest management to stop the spread of PWN, and to implement (carry on) sustainable forestry in areas with PWD. In the presentation I will pinpoint some key problems in the management of PWN-infested forests and discuss possible solutions.

PWN, PWD, pest management, Monochamus spp.

All Division 7 (Forest Health) Meeting

122 - Invasive species surveillance: New methods and tools for survey and early detection

K9 (Konzerthaus Freiburg)

IUFRO17-2441 **Sentinel plantings provide early warning against alien tree pests prior to their arrival**

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Abstract: The international trade in live plants is an important pathway for the introduction of invasive pests and pathogens of woody species. Many introduced pests and diseases were unknown, or not known to be harmful, and were not regulated before they invaded. This indicates that the current system to identify harmful species does not provide sufficient protection from invasions by alien pests and pathogens. Potentially harmful organisms for regulation can be identified by monitoring trees planted in regions that export plants, for example in botanical gardens, arboreta or sentinel nurseries created for this purpose. Moreover, depending on whether the monitored plants are native or exotic to the country where the sentinel planting is located. COST Action "Global Warning" has established a global network of scientists and regulators in countries where sentinel plantings could be established, develops common protocols for the monitoring and identification of pests, and explores ways to regulate the establishment of such sentinel nurseries and the use of data collected in sentinel plantings. The Action will also collate detailed information about the international live plant trade and the environmental value of woody plants in Europe.

Potential pest, international trade, live plants

K9 (Konzerthaus Freiburg)

IUFRO17-343 **Identification and Use of Pheromones in Detection and Management of Cerambycid Beetles**

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Abstract: Cerambycid beetles have the potential to be highly invasive because of the ease with which their larvae are moved around the world by international commerce, in wood products, pallets, dunnage, or other wooden materials. Contrary to earlier expectations, in the past decade it has become abundantly clear that many if not most cerambycid beetles use aggregation or sex pheromones to bring the sexes together for mating. Thus, as with other insect taxa, these pheromones can be exploited as sensitive and selective tools for detection, monitoring, and management of both native and invasive cerambycids. The pheromones may be particularly important tools for detection and eradication of new incursions of invasive species. We will summarize the results of recent research on the identification, synthesis, and development of applications for cerambycid pheromones, with a particular focus on pheromones of invasive species. We will also describe concomitant advances in trap and lure design which have greatly increased the efficiency of traps in catching and retaining beetles. Examples of recent and ongoing pheromone identifications will be described.

cerambycid, pheromone, surveillance, monitoring

K9 (Konzerthaus Freiburg)

IUFRO17-127 **Factors Affecting the Efficacy of Detecting Forest Coleoptera in Traps - A Meta-Analysis**

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Abstract: A large literature on the survey and detection of forest Coleoptera and their associates exists. Identification of patterns in the effect of trap types and design features among guilds and families of forest insects would facilitate the optimization and development of intercept traps for use in management programs. This presentation will review the literature on trapping bark and woodboring beetles and their associates and present the results of meta-analyses to examine patterns in effects across guilds and families. The following general patterns were observed: (1) panel traps were superior to multiple-funnel traps, (2) bark beetles and woodborers were captured in higher numbers in traps treated with a surface treatment to make them slippery than were captured in untreated traps, (3) panel and multiple-funnel traps equipped with wet cups outperformed traps with dry cups, (4) black traps were superior to white and clear traps, and (5) purple traps were as good as or superior to green traps for Agrilus spp.

bark beetle, woodborer, biosecurity, IPM

All Division 7 (Forest Health) Meeting

122 - Invasive species surveillance: New methods and tools for survey and early detection

K9 (Konzerthaus Freiburg)

IUFRO17-3931 **Combining lures for more effective surveillance of invasive wood borers and bark beetles**

Brockerhoff, E.* (1); Chase, K. (2); Ide, T. (3); Jactel, H. (4); Kimberley, M. (5); Liebhold, A. (6); Okabe, K. (3); Stringer, L. (7)

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Abstract: Biological invasions are a major concern affecting the health of forests worldwide and causing substantial costs to society through a range of direct and indirect damages. Wood borers and bark beetles are among the most serious invaders of forests, with some species causing major damage and widespread tree mortality. Although phytosanitary measures have been implemented to reduce the spread of such pests, the ongoing increase in international trade necessitates additional biosecurity measures. Eradication has become an increasingly successful response to incursions but early detection is essential. To enable more cost-effective surveillance and early detection of a wider range of potential invaders, we tested various combinations of pheromones and kairomones that are known attractants for unwanted wood borer and bark beetle species. Trap catches to combinations of lures were compared with catches to lures for particular species to determine whether it is possible to conduct surveillance simultaneously for multiple species using a single lure combination. The results of trapping experiments carried out in France, Japan and the United States will be presented along with recommendations for surveillance trapping programmes targeting such species.

invasive species, surveillance, attractants

K9 (Konzerthaus Freiburg)

IUFRO17-1869 **The effect of forest landscape, trap height, trap color and lure on longhorn beetle communities detected in survey traps**

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Abstract: Longhorn beetles (Cerambycidae) are among the most diverse of insect groups and include pests able to kill living trees or damage trees felled for lumber. Furthermore, they can be moved among countries within almost all kinds of wood products commonly associated with international trades (i.e. crating, dunnage or pallets). The continuing threat posed by non-native and potentially invasive longhorn beetles and the critical need for their survey and early detection lead us to investigate factors affecting their catch in traps. In summer 2016, eight Lindgren funnel traps (green vs. purple) baited with ethanol vs. ethanol plus a pheromone blend were placed in the understory and the canopy to sample the communities of longhorn beetles in each of seventeen sites (natural forests vs. plantations), along gradients of area and connectivity with other forest patches. We expect to find that a) color, height, and lure blend can strongly affect trapping efficiency in terms of species richness, species composition, and abundance; b) both area and connectivity can positively affect longhorn beetle catches, i.e. highest species richness and diversity in large patches highly connected with other patches. This information will prove useful for enhancing early-detection strategies and interception protocols for non-native longhorn beetles.

Cerambycidae, Surveillance, Trapping

K9 (Konzerthaus Freiburg)

IUFRO17-866 **Recent improvements in trapping methods for surveillance of bark and wood boring beetles**

Sweeney, J.* (1); Silk, P. (1); Webster, R. (1); Mayo, P. (1); Hughes, C. (1); Gutowski, J. M. (2); Mokrzycki, T. (3); Miller, D. (4); Ryall, K. (5); Meng, Q. (6); Yan, L. (6); Francese, J. (7)

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Abstract: Non-native bark- and wood boring beetles continue to be moved intercontinentally in solid wood packaging in spite of international phytosanitary regulatory policies, and some of these may become invasive pests. Early detection of established invasive species is critical for their effective eradication, containment, or management. Data from field experiments in North America, Poland and northeast China show that trap height and trap color significantly affect the efficacy of detecting species of Cerambycidae, Buprestidae, and Scolytinae in Lindgren funnel traps. Green traps detected more buprestid species than did black or purple traps whereas trap color had little effect on Scolytinae detection. The effect of trap color on cerambycid detection varied among sites: green traps detected more species than black or purple traps in Poland and Canada whereas the reverse was true in China. Traps in the canopy detected more buprestids (as well as cerambycids at some sites) than did traps in the understory but the reverse was true for scolytines. Our data suggest that efficacy of trapping surveys for detection of non-native bark- and wood boring beetles is increased by using > 1 trap color and by placing traps in both the canopy and understory.

trap survey, color, height, cerambycid, buprestid

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122 - Invasive species surveillance: New methods and tools for survey and early detection

K9 (Konzerthaus Freiburg)

IUFRO17-3120 **High catches in North America and in China show that traps and lures developed and used in Europe are efficient for detecting exotic Monochamus spp. vectors of Bursaphelenchus xylophilus**

Boone, C. (1); Grégoire, J.-C.* (1); Bentz, B. (2); Berkvens, N. (3); Casteels, H. (3); Drumont, A. (4); Hughes, C. (5); Maclauchlan, L. (6); Silk, P. (5); Stephen, F. M. (7); Sweeney, J. (5); Webster, R. P. (5); Zhao, B. (8)

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Abstract: Pine wilt disease is caused by the pinewood nematode (PWN), Bursaphelenchus xylophilus, which is vectored by Cerambycids of the genus Monochamus throughout its native (North America) and introduced (Japan, China, Korea, Taiwan, Portugal) ranges. Despite strict import regulations and phytosanitary measures, PWN and Monochamus species continue to move worldwide. Following its introduction in Portugal in the late 1990s, extensive monitoring of PWN and its vectors is carried out throughout the European Union, using locally developed and tested lures and traps.
European trapping systems composed of a Crosstrap and Galloprotect Pack lures were deployed in two locations in the USA, two locations in Canada and one location in China in order to test their capacity to detect Monochamus species exotic to Europe.
Large numbers of M. carolinensis, M. mutator, M. notatus, M. s. scutellatus, M. clamator and M. titillator were trapped in North America, whilst large numbers of M. alternatus were trapped in China.
The trapping systems developed in Europe for detection of European Monochamus spp. are thus also effective for the detection of many broadly distributed exotic Monochamus species and could be used as monitoring tools for quarantine vectors in European ports and other points of entry.

Pine wood nematode; Monochamus spp.

All Division 7 (Forest Health) Meeting

146 - Climate change and air pollution impacts on forest health status and productivity

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1404 **Biogenic Organic Aerosol as an indicator of the forest abiotic stress**

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Abstract: Volatile organic compounds (VOCs) have a substantial impact on the oxidant balance of the lower layers of the atmosphere. As result, they affect tree growth and ecosystem performance. Also, VOCs play significant role in new particle formation process and they change physicochemical properties of the existing particles. Wherein, such ecosystem like forest are the main source of the biogenic VOCs and in the global scale their emissions higher than anthropogenic VOCs. Thus, we investigated the changes of the physicochemical properties of the aerosol particles in forest environment. The measurements were performed applying a Scanning Mobility Particle Sizer, an Aerodynamic Particle Spectrometer and an Aerosol Chemical Speciation Monitor. During measurement campaign, it was observed new particle formation phenomena. Fresh nucleated particles were characterized by low oxidation level and high particle number concentration of the nucleation mode. Wherein, the polydisperse coagulation process was much higher than the condensation growth of the nucleated particles. Also, we determined that the nucleation process of the aerosol particle was related with the trees abiotic stress, which was observed by temperature increase. The analyse of the aerosol mass spectra showed that the methanol (CH3OH, m/z 33), acetone (C3H6O2, m/z 59), methyl-ethyle-ketone (C4H8O, m/z 73) and salicyl-aldehyde (C7H8O2, m/z 123) emissions were identified as heat related. Meanwhile, methanol, acetone and methyl emissions showed great dependency of heat and light. They showed high correlation (>0.9) with one another. However, the salicyl-aldehyde could be assigned to heat stress marker. Thus, we can conclude that biogenic organic aerosol particles can be an indicator of the abiotic stress of the forest and that could to expand understanding of the forest ecosystem. The study is based on the results from national project supported by Lithuanian Council of Research "FOREstRESS" (SIT- 3/2015).

forest health, abiotic stress, organic aerosol

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1036 **Change in Sulphur pools in forest ecosystems following the reduction of atmospheric SO2**

Prescher, A.-K.* (1); Schmitz, A. (1); Johnson, J. (2); Vanguelova, E. (3); Cools, N. (4); Gottardini, E. (5); Nieminen, T. M. (6); Schaub, M. (7); Ukonmaanaho, L. (6); Verstraeten, A. (4); Waldner, P. (7); Seidling, W. (1)

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Abstract: Due to the reduction in sulphur emissions from transport and industry, atmospheric sulphur dioxide (SO2) concentrations and sulphur deposition in Europe decreased significantly in the last decades. Sulphur is an essential plant nutrient needed for the production of certain amino acids. Its compound sulphate is the principal anion in soil solution and a driver of base cation and aluminium leaching from soils. However, few studies have examined changes in sulphur pools in forest ecosystems as a response to reduction of dry and wet S deposition. Within the monitoring framework of ICP Forests (International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests) sulphur compounds in soil, soil solution, biomass and deposition have been measured many years across Europe, allowing for the evaluation of sulphur pools and dynamics. In this study, we quantified the change in sulphur pools (forest floor, mineral soil, soil solution, tree biomass and litterfall) between 2007 and 2014 across Europe, focusing on ecosystems dominated by European beech, Norway spruce and Scots pine. Results show how the magnitude of decline in S deposition and atmospheric SO2 concentration as well as climate, species and soil characteristics moderate sulphur cycling in forest ecosystems, while the absolute effect can differ due to site-specific aspects like management or understory vegetation. The results inform our understanding regarding the long-term effects of elevated SO2 concentrations and deposition and help to evaluate the time scales and magnitude at which the main forest ecosystem compartments react to changes in sulphur exposure. Eventually, consequences for forest ecosystems in countries with ongoing sulphur emissions to the atmosphere may be predicted. On the other hand, the results may be used to improve predictions of forests likely to become deficient in S.

air quality, sulphate, trend analysis, ICP Forests

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2344 **Forest ecosystem status in the Romanian LTER sites under the air pollution and climate change stress**

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Abstract: The research carried out in the Retezat and Bucegi-Piatra Craiului mountain forests (Southern Carpathians) provides scientific support for Romanian long-term ecosystems research (LTER) and is of multi- and transdisciplinary nature. It includes monitoring and evaluation of forests ecosystems status under air pollution and climate change effects. During the last period 2009-2016, forests in the Retezat LTER site were moderately affected by excessive drought, high temperatures, air pollution and other natural stress factors, resulting in 12,1 - 16.7% of trees as damaged (crown defoliation greater than 25%). In Bucegi - Piatra Craiului LTER site the percentage of damaged trees decreased from22.5% (2009) to 16.7% (2016). European beech (Fagus sylvatica) was the least affected species, with 8.0-10.2% of trees in defoliation classes 2-4 in Retezat and 11.3 % (2009)- 8.1% (2016) in Bucegi - Piatra Craiului site, while Norway spruce (Picea abies) were much more stressed (12.9 - 21.2%) both in Retezat and Bucegi - Piatra Craiului (27.7 - 22.7%), Mountains. The elevated intensity of damage caused the annual volume growth losses for the entire research forest areas up to 25.0%. The nutritional status of trees was within limits of normal values, without any apparent influence on tree physiology. Soil acidity was typical for the types of geological materials found in the Retezat and Bucegi-Piatra Craiului Mountains indicating a slow negative effects of atmospheric acidic deposition. High diversity and evenness specific to the stand type's structures and local climate conditions were observed within the herbaceous layer, indicating that biodiversity of the vascular plant communities was not compromised.

LTER, forest status, soil, biodiversity, growth

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146 - Climate change and air pollution impacts on forest health status and productivity

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-460 **Long-term impacts of ozone and climate change on forest productivity and dynamics in Switzerland: a hybrid modeling approach**

Cailleret, M.* (1); Haeni, M. (1); Bugmann, H. (2); Büker, P. (3); Emberson, L. (3); Rigling, A. (1); Simpson, D. (4); Solly, E. (1); Waldner, P. (1); Gessler, A. (1); Schaub, M. (1)

(1) Swiss Federal Research Institute WSL, Birmernsdorf, Switzerland; (2) Department of Environmental Sciences, ETH Zürich, ZURICH, Switzerland; (3) Stockholm Environment Institute, University of York, York, United Kingdom; (4) EMEP MSC-W, Norwegian Meteorological Institute, Oslo, Norway

Abstract: Tropospheric ozone (O3) has large impacts on plant metabolism and functions at the individual tree level. However, because of potential compensatory effects such as changes in species composition, it is not clear if these modifications can induce long-term changes in functions and dynamics at the community scale. Moreover, ozone is only one of the multiple environmental stressors that affect ecosystem processes, and its relative importance has never been quantified. This is of key importance especially as ozone concentration levels are projected to change dramatically in the next decades in concert with climatic conditions.
In the context of the SwissForestLab, we developed a hybrid model that couples the physiological process-based DO3SE model with the forest succession ForClim model to assess the impact of ozone-induced reductions in annual tree growth on long-term stand-scale forest productivity. The model was applied to simulate the future development of monospecific and mixed stands representative of the diversity in forest types in Switzerland, considering multiple climate change scenarios.
The simulations highlight that the decrease in stand productivity caused by ozone may be partially compensated by a reduced strength of the intra- and inter-specific competition and is rather small in comparison to the potential effects of changes in climatic conditions and in forest management practices.

Ozone, forest, growth, model

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-556 **Climate change-related dieback of evergreen conifers and adaptation options**

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Abstract: Heat and drought induced mortality of trees are increasing worldwide due to climate change. In Korea, mass mortalities of pines including Pinus densiflora and P. koraiensis due to heat and drought stress have been occurred recorded frequently from late 1990s. P. densiflora trees were damaged even though they are living in edaphically dry conditions, while deciduous trees were survived. Mechanism of the mortality is carbon starvation in cases of coupling of prolonged drought and warmth in late winter and early spring before ectomycorrhizal forming of pines while deciduous trees avoid drought stress by absence of leaves. According to our test in laboratory for ten species of ectomycorrhizal fungi, mycelial growth initiated at and higher than 8 degree C. Due to the climate change, winter temperature is increasing more rapidly than other seasons without precipitation increase while summer precipitation is increasing more than other seasons in Korea. Future climate change scenarios projected as the same trend with the past decades. To adapt to the future climate for maintaining forest health, productivity and biodiversity, early actions on thinning for dense and plantation forests and diversifying forest type and stand structure and amelioration of age class distribution in landscape level are strongly recommended.

Drought stress, Mycorrhizae, Mortality

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2128 **The response of intra-annual stem circumference of prevailing in Lithuania tree species to meteorology and air pollution under different site condition**

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Abstract: Global change in Lithuania is predicted to promote increasing air temperature across seasons, a decrease in snow cover and an increase in heavy rain as well as more frequent drought events. Changes in atmospheric circulation reduce seasonal climatic amplitudes, but enhance air pollution most presumably induced by ozone, acidification and UV radiation which in turn will affect tree growth and ecosystem performance in general. Intensive investigations at selected different humidity and nutrition regime forest sites combine seasonal growth of Scots pine, Norway spruce, and silver and downy birch trees analysis with ecophysiological assessments of tree water consumption under the presses of different environmental conditions. Significance of the effect of the hourly, daily and weekly data on intra-annual stem circumference was esteblished. We hypothesized that Scots pine is becoming a climax tree species under progressively declining soil water availability, while Norway spruce is more sensitive to short term drought events on water limited sites than pine and birch trees, whereas birch trees are more sensitive to short term drought events on eutrophic peat sites in Lithuania. The obtained data on intra-annual stem circumference revealed that coniferous tree species were more sensitive to environmental changes than broadleaf tree species like birch trees due to their lower transpiration rates. The study is based on the results obtained conducting national project supported by Lithuanian Council of Research "FOREstRESS" (SIT-3/2015).

intra annual stem growth, sapflow, stress factor

All Division 7 (Forest Health) Meeting

188 - Managing pests and diseases in commercial plantations

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3350 **A new threat for Eucalyptus plantations in Uruguay: Teratosphaeria pseudoeucalypti the causal agent of Teratosphaeria Leaf Blight**

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Abstract: Teratosphaeria pseudoeucalypti was first described in 2010, causing Teratosphaeria Leaf Blight (TLB) in Queensland, Australia. In 2014 it was reported simultaneously in Argentina, Brazil, and Uruguay, representing the first detection of this pathogen outside of Australia. However, the impact of this disease on Eucalyptus plantations is still unknown. The aim of this study was to characterize the population of this pathogen in Uruguay as well as the resistance of different Eucalyptus species tested under field conditions. A national survey was conducted in 2015 to collect symptomatic leaves and to isolate the pathogen. Multigene analysis of 24 isolates based on ITS, BT, ATP6 and EF1, confirmed the identity of all isolates as T. pseudoeucalypti. All isolates grouped with haplotype KE8 according to Andjic et al. 2010. Susceptibility of different Eucalyptus species was tested under natural inoculation on three field experiments. At least two genotypes of each Eucalyptus species were tested. Significant differences on disease severity was observed among tested species. Eucalyptus camaldulensis was the most susceptible one, followed by E. tereticornis, and E. globulus, whereas E. maidenii, E. grandis, and E. dunnii showed the lowest disease severity. Even though the disease was observed infecting all species, our results suggest that TLB represents a serious threat to E. camaldulensis, E. tereticornis and E. globulus, while might represent a minor disease for E. maidenii, E. grandis and E. dunnii

genetic resistance, invasive species, epidemiology

K 2-4 (Konzerthaus Freiburg)

IUFRO17-356 **Management of red needle cast caused by Phytophthora pluvialis**

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Abstract: Red needle cast, caused by the pathogen Phytophthora pluvialis, is a disease which can cause needle loss in Pinus radiata. Aerial Phytophthora diseases are more recent occurrences in pine plantations and this has provided challenges in understanding their dynamics in the field and developing appropriate management options. Disease expression and pathogen presence has been monitored since red needle cast was first detected in New Zealand, and these results are being used to inform control strategies. Initiatives to screen breeding material in the field and in in vitro detached needle assays to identify a range of material that show varying levels of resistance have so far been successful. However, new evidence suggests that a number of other factors, along with visual observations of lesion development, can be used to determine levels of resistance. Specifically some of the drivers of pathogen epidemiology have the potential to be manipulated and may play a critical role in the control of this disease. Other forms of management being investigated for red needle cast include chemical and biological control. It is expected that the use of a combination of these methods in an integrated pest management approach should be successful in controlling this disease.

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2302 **Enhancing biological control in short rotation coppices: possibilities and limitations**

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Abstract: Insect pests can strongly influence the economic outcome of short rotation coppices. Chemical control is often complicated due to the height of the trees and the prohibition of aerial spraying of pesticides by the German legal framework. Therefore, non-chemical measures to reduce the populations of pest insects are in focus of current research. Habitat manipulation is one key element to enhance biological control with the aim to supress the damage through pest species below the economic injury level. As an example, the influence of the presence of different food sources on longevity and fertility on the pupal parasitoid Schizonotus sieboldi (Pteromalidae), an important antagonist of the leaf beetle Chrysomela populi, will be presented. We found that the longevity of female S. sieboldi individuals can be prolonged from 4 ± 1 days without food to 31 ± 12 days with Galium album, which was proved to be the best out of seven food sources. Furthermore, an overview of additional possible measures to enhance biological control is given and known problems and limitations will be discussed. We conclude that it is possible to promote natural enemies in short rotation coppices through habitat manipulation. However, pest management becomes more and more complicated and requires high level of expertise of the land managers.

insect pest, biological control, flowering plants

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188 - Managing pests and diseases in commercial plantations

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2304 **Biological control of Thaumastocoris peregrinus Carpintero and Dellappé (Heteroptera: Thaumastocoridae): towards the development of a mycoinsecticide**

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Abstract: The bronze bug, *Thaumastocoris peregrinus* (Heteroptera: Thaumastocoridae) is a small sap feeding hemipteran bug that has become a serious pest of *Eucalyptus* plantations worldwide. Affected trees display foliage blight and defoliation, thus reducing photosynthesis and sometimes leading to the death of those highly infested mature trees. The use of entomopathogenic fungi as biological control agents is seen as an environmentally friendly alternative for pest control being chemical control seldom used in commercial forestry because its environmental and economical disadvantages. In this study, naturally occurring entomopathogenic fungi on *T. peregrinus* were isolated from dead and mycosed insects found in *Eucalyptus* plantations in Uruguay. Fungal species were identified based on spore and reproductive structures, morphology, culture characteristics, and molecular identification by amplification of the ribosomal DNA comprising ITS1, ITS2 and the 5.8S subunit. The identified entomopathogenic species belong to the genera *Beauveria*, *Isaria*, *Lecanicillium*, *Purpureocillium* and *Pochonia*. Bioassays using fifty-eight entomopathogenic fungal isolates from bronze bug and other forestry and agricultural pest insects were performed to determine their pathogenicity and virulence against *T. peregrinus*. A first *in vitro* screening was made by spraying 10^7 conidia/ml suspensions onto adults of *T. peregrinus* reared in mesh cages on detached leaf- bearing twigs of *E. tereticornis*. Isolates were classified into four categories based on the number of days to reach 90% of mortality. Most of the tested strains (80%) were pathogenic to bronze bug showing different degrees of virulence. For a subset of strains, values of LC_{50} and LT_{50} were determined. In addition, the most promising strains are being subjected to mass production studies in order to identify cost-effective production methods and to select the most stable and virulent formulated strains.

Thaumastocoris peregrinus, entomopathogenic fungi

K 2-4 (Konzerthaus Freiburg)

IUFRO17-4109 **Picea abies stump size and efficacy from treatment with Phlebiopsis gigantea and urea against Heterobasidion in Sweden**

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Abstract: Norway spruce (Picea abies), the most important planted commercial species in northern Europe, is under a constant threat from Heterobasidion root rot that is worsened by year-round cuttings and prolonged growing seasons. Heterobasidion can spread not only from spore infections on bigger sized Norway spruce stumps created in e.g. thinnings, but also from smaller sized stumps. Preventive action should therefore be taken also at pre-commercial thinning through stump treatment. Anecdotal data indicates though a reduced effect on smaller sized stumps. In Sweden two agents with different modes of action, urea and Phlebiopsis gigantea, are used at stump treatment, possibly with different efficacy at different sizes of stumps. The agents' efficacy were compared on smaller Norway spruce stumps ranging from 2-16 cm in diameter. The efficacy increases with stump size for Phlebiopsis while urea works perfect all over. The relevance of the influence of size can however be questioned since the smallest stumps had comparably low probability of getting infected, i.e. a low efficacy for small stumps is of less importance since only few stumps get infected. Conclusively it seems prudent and possible to treat also smaller sized stumps but stumps with a diameter of 80 mm or less may not be economically beneficial to treat.

stump treatment, efficacy, root rot, management

K 2-4 (Konzerthaus Freiburg)

IUFRO17-877 **Productivity losses caused by Teratosphaeria nubilosa on Eucalyptus globulus and Eucalyptus maidenii in Uruguay**

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Abstract: Teratosphaeria nubilosa severely affects young plantations of Eucalyptus globulus and E. maidenii in Uruguay. This work analyzes the effect of this pathogen on the growth and survival of both species, based on data from a naturally infected field trial. The degree of defoliation was quantified at 21 months old, and its effects on diameter and mortality were evaluated at 62 months old. Defoliation in E. globulus was higher than in E. maidenii, with an average of 52.5 and 28.8%, respectively. Four years after the epidemic, defoliation classes of 40% or higher had significant growth losses on E. globulus, while losses in E. maidenii were significant when defoliation was 30% or higher. An average loss in DAP of 27.5 % in E. globulus and 12.5 % in E. maidenii was observed. The most affected trees, with 70-80% of defoliation in E. globulus and 60% in E. maidenii, had similar growth loss in both species, suffering a reduction in DAP of 43.9% and 42.5%, respectively. By contrast, the average mortality that occurred between 21 and 62 months old was significantly higher in E. globulus (16.7%) than in E. maidenii (3.3%). Mortality in the higher defoliation classes reached 44.7% on E. globulus and 47.1% on E. maidenii. Although E. globulus showed greater susceptibility to the disease and higher productivity losses, the significant defoliation and growth losses registered in E. maidenii suggest that this species is not as suitable as previously thought to replace E. globulus on sites with high risk of T. nubilosa.

disease, defoliation, growth losses, mortality

All Division 7 (Forest Health) Meeting

122 - Invasive species surveillance: New methods and tools for survey and early detection

K9 (Konzerthaus Freiburg)

IUFRO17-1853 **Biosurveillance of Alien Forest Enemies (bioSAFE) - creating new genomic tools to meet the challenges posed by forest alien invasives**

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Abstract: The world's forests face unprecedented threats from invasive insects and pathogens. This threatens the ecological and economic stability of our natural and urban forests. New introductions and interceptions of Forest Invasive Alien Species (FIAS) are escalating at an alarming rate and managing this risk requires vigilant biosurveillance. Prevention and early detection are keys to successful biosurveillance programs, but are challenging to achieve. We will address these challenges by developing a biosurveillance pipeline to rapidly generate genomics tools that will provide: 1) accurate identification; 2) assignments to source populations and invasion pathways; 3) identification of Fitness and Outbreak-related Epidemiological (FORE) traits that can impact invasion outcomes; 4) reduced uncertainty of invasion outcomes and can inform decision support systems; 5) transferable biosurveillance tools to end users. In Canada four FIAS have been identified as current and urgent threats: Asian longhorned beetle, Dutch Elm disease fungi, Sudden oak death pathogen, and Asian gypsy moth. We will develop a biosurveillance pipeline using genomic tools developed for these four species to speed up and inform novel decision-support systems for FIAS mitigation and management.

diagnostics epidemiology WGS GBS target enrichment

K9 (Konzerthaus Freiburg)

IUFRO17-1441 **Portable LAMP (loop mediated isothermal amplification): a new molecular assay to detect Phytophthora ramorum **

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Abstract: Plant health emergencies due to invasive pathogens have increased in Europe as in others countries. These pathogens can cause huge ecosystem changes and biodiversity losses if introduced to areas with suitable conditions and potentially susceptible hosts. To contain the environmental and economic damage that they may cause in forests and urban environments, specific and sensitive diagnostic tools are necessary. An effective plan for early warning and rapid response is a crucial element of any policy aimed at reducing impacts of biological invasions or preventing the establishment of pathogens as *P. ramorum*, a recently described quarantine species that causes mortality on conifer and native broadleaved species in California (mainly *Lithocarpus densiflorus* and *Quercus spp.*), and on ornamental plants (mainly *Rhododendron* and *Viburnum spp.*) in Europe. PCR-based methods are often favored for their sensitivity and specificity but require a well-equipped laboratory. Advantages might be gained from moving testing closer to the site of sampling, reducing delays. A diagnostic assay based on LAMP (Loop mediated isothermal amplification) was developed to detect *P. ramorum*. The assay, optimized on the portable instrument Genie II (Optigene, UK) and based on ITS2 target region, can recognize the pathogen with a high level of specificity (only *P. ramorum* was identified with a melting temperature of 88,7 °C) and sensitivity (DNA was detected as low as 0,128 pg/ µl), results that equal those obtained with the *P. ramorum* qPCR diagnostic assay. The use of LAMP method for detecting quarantine pathogens like *P. ramorum* on symptomatic and asymptomatic samples, could assist to check imported and exported live plants for planting, limiting the uncontrolled spread of these pathogens. Great simplicity, sensitivity and specificity, high speed (only 30 min) and minimum required equipment make the assay ideal for application in the field and for routine plant testing both in cities and forests.

Early detection, in field diagnostic

All Division 7 (Forest Health) Meeting

122 - Invasive species surveillance: New methods and tools for survey and early detection

K9 (Konzerthaus Freiburg)

IUFRO17-3773 **Spore trapping and high throughput molecular detection approaches for forest pathogens.**

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Abstract: With the advent of high throughput methods in molecular biology it has become feasible to detect pathogens in very high numbers of samples from the environment. This can e.g. be when following movement of invasive species, or to monitor emerging outbreaks of disease. We have evaluated different methods to efficiently capture and identify fungal pathogens in a systematic manner. In order to do this we have placed a range of different types of active and passive spore trapping devices in forests, open fields, rivers, and nursery settings. The traps have collected airborne and waterborne spores over periods of days to more than three years to be able to evaluate diurnal and seasonal variation. Following DNA extraction, amplicons of primarily the ITS region of the ribosomal DNA have been obtained both using general and species specific priming approaches. Massive parallel sequencing has been carried out using 454 pyrosequencing, Illumina Hiseq and PacBio methodology. The resulting DNA sequences have been clustered and identified to the closest taxonomic level using bioinformatic pipelines. Overall the results show a high number of taxonomic units to be captured in most habitats and that species known to be present in the sampled ecosystem are commonly captured from the spore community. There was a clear tendency for wind disseminated basidio- and ascospores to be more easily captured in active spore traps than in passive, while passive traps were relatively more efficient in capturing spores known to be spread by water splash. The size of amplicons was important for detection efficacy; Illumina sequencing discriminated against long amplicons. Although databases for identification of fungal species are still not fully populated, targeting specific species can help in detecting highly interesting aims e.g. quarantine species.

Molecular detection, barcoding, Spore traps,

K9 (Konzerthaus Freiburg)

IUFRO17-1438 **Scent detection dogs for detection of trees infested by Asian longhorned beetle**

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Abstract: Surveillance is a key element in management of the Asian longhorned beetle, Anoplophora glabripennis. Detection of infested trees depends on effective visual inspection. As one useful complementary method, dogs have been trained and employed for the detection of A. glabripennis since 2009. The method was evaluated in two test series using 10 and 14 trained dogs, respectively. In the first series, A. glabripennis scent material (frass, living larva, or infested wood plus living larva) was placed in hollow building blocks invisible for dogs and handlers. Overall sensitivity was 85-93 % (correct positives of all positives), and specificity was 79-94 % (correct negatives of all negatives). More realistic but also standardized conditions were used in the second test series. A. glabripennis frass and wood shavings were hidden on trees at height of 1.8 m or at the base. Overall sensitivity was 75-88 %; specificity was 85-96 %. Dog detection has also proven its efficiency in practice; it is regularly used in monitoring of A. glabripennis outbreak areas in Austria, Germany, and Switzerland. The method is included as complementary detection method in the EPPO standard as well as the recently revised German guidelines for A. glabripennis control.

Anoplophora, survey, invasive, scent detection

K9 (Konzerthaus Freiburg)

IUFRO17-3586 **Use of the KORINA-App for engaging citizens and agencies in detection of invasive plant species in Saxony-Anhalt, Germany**

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Abstract: One of the most important tasks for the management of alien invasive species is the surveying and mapping of their occurrences. But often enough there is a shortage of funds or personnel. Smartphone apps seem to offer an easy and cheap possibility to record species occurrences and to recruit recorders via citizen science projects.
The coordination centre for alien invasive plants in protected areas in Saxony-Anhalt (KORINA) is working since 2010 in Halle (Saale). KORINA is operated by the Independent Institute for Environmental Issues (UFU e. V.). Main task of KORINA is the implementation of the KORINA Action Plan, which includes steps to prevent new invasions, to eradicate new established species and to control widespread species.
The KORINA-App was launched in 2014 and works with android and with iOS-smartphones. It enables a fast and exact recording of sightings of 114 alien invasive plants. The sightings are being verified by the images of the recorded plants. In 2016 an evaluation of the usage of the app was conducted.
Method:
In the evaluation process the number of recordings, users and the frequency of usage were examined. Furthermore the target groups, the outreach intensity and the usage of the recorded data for invasion management were analysed.
Main results:
The KORINA-App was used by the KORINA team, in school projects, by agencies and volunteers. In 2016 there were only a few continuous users, because members of the main target group of volunteers, conservationists, do not yet use smartphones. The intensity of the outreach to other target groups like anglers, foresters, hunters was not high enough.
Conclusions:
The utilisation of smartphone apps for recording of invasive species includes not only the development and constant updating of the app. An intensive approach to the potential users and a fostering of a continuous contact are necessary, too.

invasive species, smartphone apps, citizen science

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122 - Invasive species surveillance: New methods and tools for survey and early detection

K9 (Konzerthaus Freiburg)

IUFRO17-1055 **Finding a needle in a haystack - how to detect harmful new organisms on trees**

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Abstract: With the actual globalization and its intense trade, more and more harmful organisms reach new continents and habitats. To find such new organisms in goods and environment, different kinds of networks are the most efficient tools for early detection. In the past and today, an intense exchange between scientists help to gain information about new insect pests and diseases. IUFRO, IPPC, EPPO and other international organizations play an essential role too.
Within a country, the actual situation about new organisms should be known, the pests and diseases recognized, determined and reported. Normally countries do have quite efficient plant protection services and border controls, but they primarily focus on agriculture plants and food crops. Trees and shrubs in forests, parks and gardens are usually not in the main focus of these services.
There are different methods for early detection and determination of harmful organisms on trees. Also on national level, networking and the exchange of information, sometimes far outside official channels, are crucial. New pests and diseases often occur first in packaging wood, nurseries, garden centers, cities or private gardens, so it is important to include all potential players in a network. Very often consulting activities lead to new discoveries. It is important to provide consulting infrastructures not only for agriculture and forestry but also for the fast growing business of ornamental woody plants. During the last three decades, the "Swiss Forest Protection" group built up its network and is the national information platform for pest and diseases on trees and shrubs. For selected organisms case studies, inquiries and campaigns lead to good overlooks. New tools in determination make our work more efficient.

invasive species, methodology, early detection

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136 - Hierarchical modelling framework to quantify and forecast climate change and air pollution impacts

K 1 (Konzerthaus Freiburg)

IUFRO17-1330 **Ozone-induced stomatal sluggishness changes carbon and water balance of temperate deciduous forests**

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Abstract: Tropospheric ozone (O3) concentrations have increased by 60-100% in the Northern Hemisphere since the 19th century. The phytotoxic nature of O3 can impair forest productivity. In addition, O3 affects stomatal functions, by both favoring stomatal closure and impairing stomatal control. Ozone-induced stomatal sluggishness, i.e., a delay in stomatal responses to fluctuating stimuli, has the potential to change the carbon and water balance of forests. In this presentation, our recent experimental results and the developments for the modeling study are summarized. To discuss the effect of O3 on stomatal conductance (gs), an analytical model was proposed based on the optimization theory for maximizing carbon gain while minimizing concurrent accompanying water loss and O3 influx.
In the ozone FACE (Free-Air Controlled Exposure) experiments in Japan (Sapporo Experimental Forest, Hokkaido Univ.) and in Italy (Sesto Fiorentino, CNR campus), the optimal stomatal model explained O3-induced stomatal closure in early summer. This suggests that O3-induced stomatal closure may reduce ozone influx, and allow maximum photosynthetic capacity to be reached. However, in late summer and autumn, the model did not explain the effects of O3 on gs. Also an increase of y-intercept of the photosynthesis-stomatal conductance relationship (gmin, minimum conductance) was found. This reflects the loss of closing response of stomata by O3 (i.e., stomatal sluggishness).
On the basis of the experimental results, we examined the effects of O3-induced stomatal sluggishness on carbon gain and transpiration of temperate deciduous forests in the Northern Hemisphere by combining a detailed multi-layer land surface model and a global atmospheric chemistry model. When the process of stomatal sluggishness is included, the water use efficiency further decreased up to 20%. Our findings suggest significant impairment of forest carbon and water balances attributed by O3-induced stomatal sluggishness.

Ozone, Stomatal conductance model, Forest WUE

K 1 (Konzerthaus Freiburg)

IUFRO17-1236 **Increased cumulative O3 uptake accelerates autumn senescence in an O3-sensitive beech forest with use of CO2 flux monitoring data**

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Abstract: Ground-level ozone (O_3) concentrations are increasing over the 21st century, especially in East Asia. However, effect of elevated O_3 on forest function has not been directly assessed at the forest level. We studied on O_3 flux-based risk assessments of carbon sequestration capacity in an old cool temperate deciduous forest, consisting of O_3-sensitive Siebold's beech (beech: *Fagus crenata*), and in a warm temperate deciduous and evergreen forest dominated by O_3-tolerant Konara oak (oak: *Quercus serrata*) based on long-term CO_2 flux observations. We will introduce another story for understanding O_3 effects on forest declining: re-translocation of leaf nutrients affected by O_3 in different soil fertilities.
On the basis of a practical approach for a continuous estimation of canopy-level stomatal conductance (Gs), higher cumulative O_3 uptake (COU) with higher Gs was observed in the beech forest than that in the oak forest. Light-saturated gross primary production, as a measure of carbon sequestration capacity of forest ecosystem, declined earlier in the late growth season with increasing COU, suggesting an earlier autumn senescence, especially in the O_3-sensitive beech forest, but not in the O_3-tolerant oak forest. Accordingly, leaf mineral nutrients were more efficiently re-translocated during autumn in beech seedlings grown under elevated O_3.

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136 - Hierarchical modelling framework to quantify and forecast climate change and air pollution impacts

K 1 (Konzerthaus Freiburg)

IUFRO17-3796 **Reaction patterns of Fagus sylvatica L. and Picea abies Karst. in Switzerland to various environmental factors derived from growth data**

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Abstract: Nitrogen deposition, ozone and climate change affect forest ecosystems in Europe. Understanding their direct effects and interactions on tree growth is important for planning of forest management and for the application of climate models. We used observational data of mature forests for studying associations of various biotic and abiotic factors with tree growth. A 30 year time series on basal area increment of Fagus sylvatica L. and Picea abies Karst. in Switzerland was analyzed to evaluate the development in relation to a variety of predictors. N deposition up to a level of about 25 kg N ha 1 yr 1 initially (1984-1998) stimulated stem increment of European beech. Above this deposition level growth was clearly decreased. Later (2006-2014) the stimulation was lost but the growth decrease still present. Stem increment of Norway spruce (1995 - 2014) was stimulated up to an N deposition of about 22 kg N ha 1 yr 1 and remained at the same level at higher N inputs. The drought effect on beech stem increment was much stronger both at high N deposition levels and at unbalanced foliar N:K ratios. There was a slightly positive relation between stem increment of European beech and winter temperature which changed towards a negative relation at unbalanced N:K ratio or N:Mg ratio. In Norway spruce this relation was always negative but enhanced at higher N deposition. During the last two decades fructification of European beech has increased both in frequency and extent which has been suggested to be a consequence of warmer growing seasons. Fructification was negatively related to basal area increment. Ozone flux was significantly and negatively correlated with basal area increment in European beech. The results are relevant for understanding climate effects on European beech and Norway spruce including interactions with air pollutants. The results not only give suggestions for ecological processes but also show the potential of an integral evaluation of observational data.

growth, nitrogen, nutrition, ozone, climate

K 1 (Konzerthaus Freiburg)

IUFRO17-69 **Modelling long-term impacts of changes in climate, nitrogen deposition and ozone exposure on carbon sequestration of European forest ecosystems**

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Abstract: Biomass production of forests and the related above-ground and below-ground C sequestration is influenced by climate, air quality and soil quality. There is ample evidence for interactions between the drivers of C sequestration, being either synergistic or antagonistic. We modelled the combined effects of past and expected future changes in climate (temperature, precipitation), CO2 concentration, nitrogen (N) deposition and ozone (O3) exposure (phytotoxic ozone dose, POD) on carbon sequestration by European forest ecosystems for the period 1900-2050, using empirical relationships for tree carbon sequestration responses and a process-based approach for soil carbon sequestration. We simulated impacts with: (i) an 'interactive model' with a plausible formulation of interactions between the drivers; and (ii) a 'multiplicative model', in which the combined effect is the product of the individual drivers. Impacts of soil quality, in terms of the availability of calcium, magnesium, potassium and phosphorus, were also evaluated.
Results showed that predictions with the multiplicative model give the best comparison with growth observations at European level for the period 1950-2010. The impacts of drivers per unit change, i.e. the responses in kg C ha-1yr-1 per °C, ppm CO2, kg N ha-1yr-1 and mmol m-2 yr-1 POD are in line with published literature data. Simulations with the multiplicative and interactive model show that the estimated carbon sequestration in terms of changes in carbon pools in both forests and forest soils increased by 65% and 20%, respectively, in the period 1900-2005 and are expected to change by only 5% and 2%, respectively, in the period 2005-2050. The relative large impact in the past is mainly due to N deposition and to a lesser extent by CO2 increase. The relative small increase in the future is mainly caused by climate change counteracted by a decrease in N deposition.

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188 - Managing pests and diseases in commercial plantations

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3314 **The eucalyptus weevil Gonipterus spp. - semiochemicals with monitoring and control potential**

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Abstract: The eucalyptus weevil Gonipterus spp. (Col., Curculionidae) is a major pest of eucalyptus plantations that has spread worldwide. In Portugal, Gonipterus platensis causes economic damage to Eucalyptus globulus plantations, which account for 3% of the national exports. Although often successful, biological control fails in areas located at higher altitudes, due to a reduced efficiency of the egg parasitoids. The research conducted aimed at the identification of semiochemicals potentially applicable to the monitoring and control of G. platensis. The methodology included the collection and identification of host volatiles, followed by electro-antennographic and/or behavioural bioassays with individual compounds, or blends emitted by E. globulus. Volatiles were collected with MonotrapTM disks, extracted with dichloromethane and analysed by 1D and 2D Gas Chromatography and Mass Spectrometry (GC/MS; GCxGC/TOFMS). Simultaneous distillation-extraction (SDE) from Eucalyptus leaves using hexane was also performed, following analysis by GC-MS/EAD, GC-FID and GC/MS. G. platensis displayed EAG responses to 36 of the compounds detected, comprising monoterpenes, monoterpenoids, sesquiterpenes and sesquiterpenoids, an alcohol, a ketone and an ester. Regarding behavioural bioassays, performed in an olfactometer, five compounds proved to be attractive. No repellent effect was observed. Results indicate that host emitted semiochemicals constitute potential tools applicable in management programmes of Gonipterus weevils.

G. platensis, defoliation, attractants, GC-EAD

K 2-4 (Konzerthaus Freiburg)

IUFRO17-785 **Deep planting benefits Norway spruce seedlings**

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Abstract: Conifer seedlings are typically planted to depths of 3-5 cm in boreal forests. Given that machine planting has become more common, there is a need to demonstrate that conifer seedlings can be planted deeper using a machine without reducing field performance. To investigate the effects of deep planting on Norway spruce (Picea abies) container seedlings, we established field experiments in Central Finland. On a site with medium coarse soil, planting depths were 0, 2, 5 and 8 cm and on fine-textured soil, planting depths were 3, 6 and 10 cm. Deeper planted seedlings grew better during the first 4 years after planting and at the end of the fourth season, initial differences in shoot length among planting depths had disappeared. Incidence of insect damage was relatively low, and no differences among planting depths were found in two field experiments. Risk for pine weevil (Hylobius abietis) insect damage was also tested in a cage experiment and the number of deep gnawing scars on stems were significantly lower in deeper planted seedlings. Thus, deep planting improves growth of Norway spruce container-grown seedlings and is an advantage especially in dry conditions. However, insect damage risk from Hylastes species still needs to be studied further.

drought, pine weevil, seedling damage

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2505 **Biological control of the Eucalyptus bronze bug Thaumastocoris peregrinus with Cleruchoides noackae: setting up the rearing system**

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Abstract: The bronze bug is a global pest of eucalypt-based forestry. Its management relies on biological control with Cleruchoides noackae (Hymenoptera: Mymaridae). We describe the rearing schemes developed for both the pest and the parasitoid. The bronze bug was reared in separate units for eggs, nymphs and adults. Oviposition was tested on different Eucalyptus species in order to maximise in vitro egg production. Eggs obtained from the rearing colony were then offered to C. noackae for parasitization. Wasp production units consisted of plastic vials containing host eggs, recently emerged adults of C. noackae, and a paper embedded in honey solution. We compare wasp sex ratio, emergence and parasitization under different temperatures, number of egg offered and individuals per production unit. Additional emergence devices were set up for mass production during release periods. Incubation of 1,500 eggs of the bronze bug allows an average weekly production of 7,500 eggs ready for parasitization. Eucalyptus tereticornis was chosen for the rearing, as T. peregrinus females laid more eggs on this species. Under 25 ºC and 55 % RH, eggs started hatching on day six, and the first adults were obtained 17 days later. Preparation of 80-100 production tubes and 10 emergence devices per generation produced enough wasps for field release. Wasps reared under 22 º C and 60% RH emerged on day 19. Sex ratio was 0.40 and it remained stable after more than 30 generations. Emergence rates fluctuated between 20 and 60%. The maximum estimated parasitization rate was 75 %. Emergence was higher on production units containing 7 females and 50 eggs. Optimisation of both rearing schemes provides a useful tool towards the implementation of biological control of the bronze bug.

Biological control, rearing, parasitoid, Uruguay

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188 - Managing pests and diseases in commercial plantations

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3152 **Heterobasidion And Armillaria Root And Stem Rot Diseases In Turkish Forests**

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Abstract: Turkey has a land area of 78.5 million hectares (ha), of which 21.7 million ha is forested (approximately 27.6 %). Pinus brutia is the most widespread native pine species (6 million ha), followed by Pinus nigra ssp. pallasiana (4.6 million ha) and Pinus sylvestris (1.5 million ha). In addition to pines, Abies nordmanniana, Abies cilicica, Cedrus libani and Picea orientalis are important conifers in Turkish forests.
Root and stem rots caused by Heterobasidion and Armillaria species are economically the most significant and destructive diseases of coniferous forests in the Northern Hemisphere. To date, two Heterobasidion species have been found in Turkey. Heterobasidion abietinum is a common root and stem rot fungus on A. equi-trojani, A. bornm ülleriana and A. nordmanniana in northern Turkey and on A. cilicica in the Mediterranean region. Estimated incidence of annosum root and stem rot on fir was 10-30% indicating a significant level of damage in these forests. H. annosum s.s. was recorded on stumps of A. nordmanniana ssp. nordmanniana in Ordu and G ümüshane provinces in north-eastern Turkey and isolated from dying P. brutia in Burdur-G ölhisar in the Mediterranean region. However, reports of disease centres in pine forests are scarce.
Armillaria root disease can cause significant damage in commercial forests. As primary pathogens, Armillaria spp. cause lethal disease, invading and killing the living bark and cambial regions of roots and the root collar. Occasional reports have indicated association of Armillaria with tree mortality in Turkish pine forests. Recently an active infection centre in a Scots pine stand was investigated in the mountains of the central Black Sea region of Turkey and the causal agent shown to be a single A. ostoyae genet, at least 0.2 ha in size.

disease incidence, genetic diversity, control

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3369 **Current status of forest plantation health in Colombia**

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Abstract: The forestry industry in Colombia is comprised of approximately 500.000 ha of native tree species as well plantations of non-native Pinus and Eucalyptus. Since 1960's, these plantations have been seriously challenged by a large group of pathogens and insect pests, including those native to the country and others that have been introduced from elsewhere in the world. Emerging diseases caused by Dothistroma septosporum, Mycosphaerella dearnessii and Fusarium circinatum represent serious threats to Pinus species. In Eucalyptus,damage due to Chrysoporthe cubensis, Botryosphaeria ribis, Ceratocystis neglecta and Puccinia psidii have increased dramatically in recent years. In addition, native insects residing in the Lepidoptera (Geometridae), Hymenoptera (Formicidae) and Phasmatodea (Heteronemiidae)have caused extensive damage to plantations of Pinus and Eucalyptus in the country. More recently, the appearance of Glycaspis brimblecombei, Pineus boerneri, Gonipetrus platensis and Malonion velezangeli have had a negative impact of the productivity of plantations. These diseases and pests have become a matter of national concern because they threaten the economic viability and long-term sustainability of the forestry industry as well as environmental and social stability. As consequence, the forestry sector has re-structured the National Forest Health Programme, including a vision for preventing new outbreaks and to implement control measures. This is mainly focused on breeding and selection of tolerant planting stock and Integrated Pest Management. Prospects for future management include robust surveillance measures and the implementation of policies to reduce the introduction of pathogens and pests that threaten plantation forestry in Colombia. Intensive research is also being carried out in an effort to improve available knowledge of the most important pests and diseases in Pinus and Euclayptus plantations and to ensure high quality management of these problems.

Emergin diseases, pathogens, planting stock, pest

All Division 7 (Forest Health) Meeting

177 - Forest Health in a Changing Climate

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3324 **The Scientific Basis of Climate Change and the Observed Impacts and Risks on Forests and Watersheds across National Forest System Lands in the United States**

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Abstract: This presentation will focus on the scientific basis of climate change, and the observed impacts and risks on forests and watersheds in the United States. The first part of the presentation will focus on the scientific basis of climate change, both the observed aspects related to increasing global temperatures and changes in precipitation patterns, as well as the scientific aspects related to the acceleration of the hydrologic cycle. The second part of the presentation will focus on efforts within the U.S. Forest Service to monitor watershed conditions, and assess and improve resilience of its 15,000+ watersheds to the impacts of climate change through its Watershed Condition Framework program.

As global surface temperatures continue to increase due to anthropogenic emissions of greenhouse gases, the observed temperature increases are enhanced in many mid- and high-latitude forest ecosystems. As part of the Forest Service's Watershed Condition Framework program, substantial efforts are underway to monitor and assess trends in the condition of its watersheds. National Forest System lands across the United States are especially vulnerable to current and predicted changes in surface temperatures, and the agency is attempting to address the increasing vulnerability by focusing watershed restoration and rehabilitation efforts in "Priority Watersheds", where different stream and aquatic management treatments can potentially decrease their vulnerability to climate change and improve overall watershed condition.

An overview of the Watershed Condition Framework program will be given, including its background, implementation and ongoing activities. Specific emphasis on the different types of restoration treatments that have been completed or are under implementation on the agency's 70+ Priority Watersheds will be described, along with examples of different treatments that potentially improve resilience and reduce vulnerability to anthropogenic climate change.

Climate Forests Watersheds Restoration

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3908 **Hotter Drought Effects on Forests - Emerging Global Patterns of Forest Stress, Disturbance, and Mortality**

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Abstract: Drought accompanied by warmer temperatures - "hotter drought" - is an emerging characteristic of climate change. Warming amplifies chronic and acute forest water stress, and increases the incidence and severity of significant forest disturbances (wildfire, insect/disease outbreaks, and drought-induced tree mortality). Although forests in many regions currently display robust growth in the absence of drought, changing global-scale patterns and trends of warming-amplified forest drought stress, disturbances, and die-off illustrate growing risks to historic forests in all biomes, including mesic ecosystems typically not considered water-limited. A synthetic review across the diverse spectrum of recent research regarding global vulnerability to forest die-off from hotter drought reveals contrasting evidence and perspectives, highlighting both potentials for extensive "tipping point" tree mortality responses from increasingly extreme climate events along with countervailing compensatory and resilience-enhancing forest processes (growth benefits of elevated [CO2] and increased water-use efficiency; compensatory physiological, morphological, and genetic mechanisms; dampening ecological feedbacks; mitigation by management). Hotter droughts pose especially strong risks to the world's largest, oldest, most venerated and valuable trees - these carbon-rich ancient forests are among the most biodiverse and rare ecosystems, irreplaceable natural archives of ecological and cultural history. Despite the many essential societal and Earth-system roles of forests, problematically large scientific information gaps and uncertainties constrain our ability to realistically project forest dynamics with anticipated climate changes this century.

hotter drought, forest health, tree mortality

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-231 **Changing disturbance regimes and their impact on the climate regulating function of forests**

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Abstract: Forest disturbances have increased during the last decades as a result of climate change, and are of increasing concern in the context of sustaining ecosystem services such as the climate regulating function of forest. Yet there is high uncertainty about the long-term effects of changing climate and disturbance regimes, given the dynamic feedbacks between climate, disturbances and vegetation. Our objectives were thus to (i) investigate the long-term effects of climate and vegetation change on forest disturbance regimes, and (ii) derive the response of climate regulating services to these changes in forest dynamics. We used the individual-based forest landscape and disturbance model (iLand) to simulate Kalkalpen National Park (Austria) and analyzed changes in the radiative forcing from forest dynamics, accounting for the effects of total ecosystem carbon storage, albedo and latent heat flux. Our simulations indicate an increase in disturbances as a result of elevated bark beetle activity during the 21st century. Negative feedbacks from a simultaneously changing tree species composition decreased disturbances in later parts of the 200 year simulation period. Both changes in vegetation and disturbance regimes had a negative effect on climate regulation. Our study thus indicates amplifying vegetation feedbacks to climate change.

albedo, bark beetles, carbon, latent heat, wind

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KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1517 **Tree mortality during drought: the biotic connection**

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Abstract: Climate change is forecasted to increase exposure of many global forests to aridity and drought and consequently accelerate tree mortality. Processes of drought-induced mortality acting on mature trees in forest environments, which include numerous biotic mortality agents and interactions, are poorly understood. The overall goal of our presentation is to highlight the current and future roles of biotic agents of drought-induced tree mortality in forest health. First, we summarize current understanding of physiological mechanisms of drought-induced tree mortality from controlled experiments; hydraulic failure at mortality is ubiquitous across many studies and multiple tree taxa; a combination of hydraulic failure and carbon starvation often occurs during mortality of evergreens and gymnosperms. Second, we discuss relationships between these physiological mechanisms and impacts of drought on tree damage from insects and pathogens. Third, we hypothesize response trends of tree damage from insects and pathogens to drought intensity. Fourth, we discuss research needed to reduce uncertainty about future roles of biotic mortality agents in forest health during a changing climate.

drought, insects, diseases, tree mortality

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3288 **Rapid phenological changes in foliar chemistry impact gypsy moth performance: Implications to altered synchrony induced by warming climate**

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Abstract: Controlled outdoor studies performed by our labs indicate that warming temperatures within the range forecasted by the end of this century will advance tree budbreak substantially more than lepidopteran egg hatch. How these resulting shifts in phenological synchrony will impact herbivory remains unknown. It seems likely that folivores could show reduced performance under such conditions, because some trees increase foliar allelochemical concentrations over the course of a growing season. However, experiments with trembling aspen reveal a very early peak in phenolic glycoside concentrations immediately after budbreak. This highly defended period coincides with the emergence of sensitive neonates by some important defoliators. After just a few days, concentrations decline to what would be interpreted as a low starting point without fine-grained sampling. The magnitude and duration of this peak vary substantially among genotypes. In contrast, nitrogen gradually declines at a relatively consistent rate throughout leaf expansion, regardless of genotype. Controlled manipulation of intervals between budbreak and egg hatch revealed differences in early instar performance between cohorts, and variable relationships among aspen genotypes, that corresponded with foliar patterns of defense chemistry and nitrogen. Thus temperature-induced changes in phenological synchrony are likely to affect herbivory differently among tree genotypes.

gypsy moth, aspen, tree defense, climate change

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-2887 **Health and growth of Betula pendula trees under the changing climate in Lithuania**

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Abstract: According to the Lithuanian Hydrometeorological Service information, mean annual air temperature in Lithuania increased by 0.7 °C during the last 50-year period. Meanwhile, mean atmospheric precipitation also increased approximately by 4%. Simultaneously, number of days with snow cover decreased by 10 days. The rising air temperature has a direct impact on the growth of leaf insect population. This study was set out to investigate the health of young and mature silver birch trees (Betula pendula Roth) under the changing climate conditions, simulating the leaf insect damage. The analysed data of mature silver birch trees was collected under the Forest Monitoring Level I of ICP-Forests program during 1991-2015-year period. The climate change simulation experiment was conducted in the laboratory, where the artificially by 25, 50 and 75% defoliated one-year-old silver birch seedlings were grown under the controlled climate conditions. In the climatic chambers, the following climate scenarios were simulated: current environmental conditions (mean temperature of 21/14 ºC (day/night) and 400 ppm CO2 concentration); B1 scenario (temperature of 23/16 ºC (day/night) and 550 ppm CO2 concentration) and A2 scenario (temperature of 25/18 ºC (day/night) and 750 ppm CO2 concentration).
The analyses of the data showed that during 1991-2015-year period the mean defoliation of mature silver birch trees ranged between 18.3-24.0%. The results of the simulation experiment suggested that young silver birch trees were able to compensate the lost foliage during one vegetation season. Birch seedlings under the higher air temperature and CO2 concentration produced by 30% more biomass. Under the current environmental conditions, defoliated silver birch trees did not accumulate more carbon in their leaves, compared with the controls. However, leaf carbon storage increased by 9% when air temperature was elevated by 4 °C and the concentration of CO2 was increased up to 750 ppm.

Betula pendula, elevated temperature, CO2, carbon

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57 - Invasive Alien Species and International Trade - Detection Prior to Introduction, Measures and Policy

K 5-7 (Konzerthaus Freiburg)

IUFRO17-882 **Identification of potentially invasive pests through sentinel plantings and surveys in botanical gardens: A manual for assessing insect and pathogen damage proposed by the COST Action "Global Warning"**

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Abstract: Identifying appropriate and effective tools for the prior warning and early detection of arrivals of exotic insects and pathogens is urgently needed but extremely challenging because the potential invaders are often unknown, sometimes even to science. Recent sentinel plantings of European trees in China, and sentinel nurseries using Chinese tree species, demonstrated one method of creating lists of insects that may need to be prevented from entering Europe but the experiments also revealed many limitations. Extensive surveys of arboreta and botanical gardens provide an alternative as illustrated by recent findings of alien seed insects. However, in both cases the definition of standardized methods allowing a quick identification of the species responsible for damage is urgently needed. Under the European COST project "Global Warning", a team of European scientists combining forest entomologists and pathologists is realizing a manual proposing standard guidelines for assessing and identifying insect and pathogen damage on tree species in sentinel designs and arboreta. The manual will be presented at the conference

invasion, insects, pathogens, sentinel plants

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2909 **Sentinel nurseries as tools for pathway risk assessment: insects found on Chinese woody plants commonly shipped to Europe**

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Abstract: Ornamental plants represent a major pathway of invasion for alien pests and diseases in Europe. Every year, the number of life plants and plants species imported to Europe increases, representing new threats for the European environment and economy. Pest risk analyses (PRAs) are increasingly being carried out to assess the risk posed by these new importations. However, these PRAs are limited by our reduced knowledge on the pests that these imported plants may carry. Indeed, most pests recently introduced to Europe on plants for planting had not been previously identified as quarantine pests and, thus, had not been subject to specific monitoring by inspection services at ports of entries.
We used the "sentinel nursery" technique for identifying Asian pests attacking local woody plant species that are imported into Europe. We established sentinel nurseries at two sites in China, with five Asian plant species commonly shipped to Europe at that time. These plants were surveyed during two years to obtain lists of potential Asian pests that can be expected on these imported commodities. These records were compared with those obtained from literature surveys, which are usually the only sources of information available to pest risk assessors.
A total of 109 and 114 insect species x hosts combinations were found on sentinel plants at the two sites. About 30% of the insect species were identified to species level. Although all these species were known from China, over 90% insect x host associations had not been found in a previous general literature survey of pests of the five plants, among which many abundant and damaging species. Over 70% appeared new to science. A quick assessment showed that 9% of the 223 insect records were considered to present a high likelihood of introduction, 8% a moderate likelihood and 83% a low likelihood. These results clearly show the benefit of the sentinel nursery technique to identify potential contaminants of plant importations.

sentinel nurseries; invasive species

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1824 **Sentinel nurseries, plantations and arboreta, different approaches to tackle potential invasive plant pathogens before they move from their area of origin: the study case of China.**

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Abstract: Recent disease outbreaks caused by alien invasive pathogens into European forests posed a serious threat to forest sustainability with relevant environmental and economic effects. Many of the alien tree pathogens recently introduced into Europe were not previously included on any quarantine lists, thus they were not subject to phytosanitary inspections. The identification and description of alien fungi potentially pathogenic to native European flora before their introduction in Europe, is a paramount need in order to limit the risk of invasion and the impact to forest ecosystems as well as the potential role as vector of exotic trees traded to Europe. To determine the potential invasive fungi, a sentinel plantation of ecological relevant EU species and a sentinel nursery of the most traded exotic trees to EU were established in China. The fungal assemblage associated with specimens was studied using biological protocols and the tag-encoded 454 pyrosequencing of the nuclear ribosomal internal transcribed spacer-1 (ITS 1). Taxa with probable Asiatic origin were identified and included plant pathogenic genera. These results indicate that sentinel plantations and nurseries may be a strategic tool to improve the prevention of bio-invasions.

Sentinel trees; Alien Invasive Pathogens; Pathways

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57 - Invasive Alien Species and International Trade - Detection Prior to Introduction, Measures and Policy

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2721 **An overview of national regulations for sentinel plantings**

Tomov, R.* (1); Eschen, R. (2); Grégoire, J.-C. (3); Nikolov, C. (4); Orlinski, A. (5); Santini, A. (6); Maaten, T. (7); Sverrisson, H. (8); Okland, B. (9); Vettraino, A. M. (10)

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Abstract: Sentinel plantings are a powerful tool to identify harmful organisms before they arrive in a country, but the use of this novel tool is limited by reduced awareness. Another limitation for the establishment of sentinel nurseries are plant health regulations that affect the import of planting material of alien species for use in sentinel plantings. However, import of propagation material is often considered low risk compared to rooted plants and more relaxed regulations may apply. Import regulations may vary among countries and special conditions for import for scientific purposes may apply. We aimed to make an overview of regulations for import and planting of propagation material for use in sentinel plantings in countries around the world. During 2016 a questionnaire survey was conducted in more than 40 countries around the world to identify national legislation on the import of seeds of exotic tree species and their use for scientific purposes in open-field situations. This study will provide an overview on regulations that need to be observed while sentinel nurseries are settled both using seeds for planting and trees grown from these seeds. The results will be a useful tool to facilitate the selection of locations for future sentinel nurseries.

biological invasions, policy, sentinel nurseries

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1518 **Sentinel arboreta as 'bridge environment' to study novel host-pathogens interactions and detect potentially alien plant pathogens**

Rodriguez, C. M. (1); Dogmus-Lehtijärvi, T. (2); Woodward, S. (3); Aday, G. (2); Oskay, F. (2); Vannini, A.* (1)

(1) DIBAF-University of Tuscia, Viterbo, Italy; (2) Dept. of Forest Engineering, Süleyman Demirel Üniversitesi, Isparta, Turkey; (3) School of Biological Science, University of Aberdeen, Aberdeen, United Kingdom

Abstract: The sentinel arboreta concept has been recently proposed as an efficient strategy to identify potential exotic plant pathogens aggressive to native tree species from a geographical area. In fact the close contact in the same arboretum of tree species from different areas in the worlds facilitates host jump by potential plant pathogens and expression of novel host-pathogen interactions. In fall 2015 a survey was carried out on about 40 different oak species from Europe, Asia and America planted together in a section of the Ataturk arboretum in Istanbul (Turkey). An array of foliar and bark symptoms were recorded on inspected oak species. Some foliar symptoms were shared among species from different geographical areas. Several fungal morphotypes were consistently associated with specific symptoms. Morphological and molecular detection were attempted to each fungal endophytes. Symptomatic and no-symptomatic tissues were processed by Illumina platform and the resulting reads elaborated by CLC software. The results indicate the efficiency of this approach to highlight the risk of host jump and insurgence of novel host-pathogen interactions between reciprocally alien species.

Alien Invasive Pathogens, Sentinel trees

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1213 **Improved sampling of pests in traded seeds and seeds from botanical gardens**

Franic, I.* (1); Prospero, S. (2); Kenis, M. (1); Allan, E. (3); Williams, W. (4); Sniezko, R. (5); Grünwald, N. (6); Fieland, V. J. (7); Press, C. M. (6); Eschen, R. (1)

(1) CABI, Delémont, Switzerland; (2) Swiss Federal Research Institute WSL, Birmensdorf, Switzerland; (3) University of Bern, Institute of Plant Sciences, Bern, Switzerland; (4) Oregon Department of Forestry, Private Forests Division, Salem, United States; (5) USDA Forest Service, Dorena Genetic Resource Center, Cottage Grove , United States; (6) USDA Horticultural Crops Research Unit, Corvallis, United States; (7) Oregon State University, Department of Botany and Plant Pathology, Corvallis, United States

Abstract: The intensification of international trade in plants is increasing tree pest introductions. In contrast, the movement of seeds has been considered comparatively safe, with fewer introductions linked to this pathway, and the regulations concerning seed movement are therefore less strict. However, the pests being transported with seeds are generally not well known and some serious pests have been already transmitted. Detection and identification of seed pests, prior to their introduction into a country, is therefore important to inform policy and develop risk mitigation measures. Here we report the first results of a study of pests in seeds of twelve tree species from three continents, obtained from commercial suppliers and botanical gardens. Seed-borne insects were revealed by x-raying and were then extracted. Fungal isolates obtained from seeds, plated on non-selective agar, were grouped by morphotype. DNA was extracted from the insects and the representative fungal isolates and group-specific DNA regions were sequenced for species identification. Moreover, entire fungal communities from each seed-lot were assessed using a metabarcoding approach.
The results will contribute to a better understanding of the importance of seeds as an introduction pathway for pests and will contribute to improving sampling designs to detect seed-borne pests.

trade, sentinel trees, pests, fungal pathogens

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K 5-7 (Konzerthaus Freiburg)

IUFRO17-1981 **Why a regional approach to management of forest pests and diseases in Eastern Africa?**

GICHORA, M.* (1)

(1) Kenya Forestry Research Institute, Nairobi, Kenya

Abstract: Trees and forests provide essential goods and services for human kind and act as reservoirs of biodiversity on earth. In Africa, they underpin development of various natural resource based sectors by providing the bulk of the energy needs, supporting crop and livestock agriculture, wildlife and tourism, water resources and livelihoods. Trees have also been widely promoted for planting in different farming situations such as in traditional systems of the tropics or by introducing them in new agroforestry technologies (intentionally) for their added benefits on farms in different agro-ecological zones of the world. Despite their importance, trees and forests are prone to destruction and removal as land is opened up for agriculture, infrastructure or urban settlement. A desk and field study was carried out in Rwanda, Kenya, Sudan and Ethiopia in 2015. The forest types covered included trees on farms, high montane, plantation, woodland and mangrove forests. In all stages, it was established that forests are faced with health challenges associated with biotic and/or abiotic factors. This matter has transboundary dimensions since these factors can occur across territorial boundaries and the associated problems manifest themselves wherever conditions are conducive in the region. Over-reliance on few exotic tree species for plantation establishment particularly compounds the issue. As technical capacity, funding and infrastructure require to be enhanced at national and regional levels, international cooperation could therefore play a useful purpose in bringing pest and disease outbreaks reported under successful integrated management.

International cooperation, forest pest management

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1471 **Population diversity and dynamics of the Asian Longhorned beetle Anoplophora glabripennis within invasive outbreaks**

Tsykun, T.* (1); Javal, M. (2); Roux, G. (3); Roques, A. (2); Prospero, S. (1)

(1) Swiss Federal Institute WSL, Birmensdorf, Switzerland; (2) Forest Zoology Research Unit, INRA, Orléans, France; (3) Forest Zoology Research Unit, INRA, University of Orléans, Orléans, France

Abstract: The Asian longhorned beetle (ALB) Anoplophora glabripennis is a well-known invasive xylophagous cerambycidae in Europe and North America. In Switzerland, in the past five years four outbreaks have been detected so far, namely two in the region of Fribourg (Br ünisried and Marly) and two in the region of Zurich (Berikon and Winterthur). In this project, we investigated the invasion genetics of ALB in Switzerland, with emphasis on population genetic diversity and dynamics within outbreaks. A total of 247 specimens sampled between 2012 and 2015 were genotyped at 13 microsatellite loci. The first analyses revealed that the outbreaks in Winterthur, Berikon and Marly originated most likely from independent introductions. In contrast, the ALB population in Br ünisried was tightly linked to that in Marly. Within outbreaks, contrasting patterns of genetic diversity were observed. In Winterthur and Berikon the ALB populations were homogeneous, whereas in Marly and Br ünisried a high genetic variation at the microsatellite loci was observed. Since the mitochondrial genome of ALB is maternally inherited and in theory non-recombining, we also characterized the female lineages present in the populations. For this, the whole mitochondrial genome of each specimen was sequenced by using a next-generation-sequencing technique and SNP sites were defined. Analyses are in progress and the results will also be presented in this talk.

invasive pests, genetic diversity

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2907 **Determinants of global variation in habitat susceptibility to insect invasions**

Liebhold, A.* (1)

(1) US Forest Service Northern Research Station, Morgantown, United States

Abstract: Insects are the most common taxon of invading species in most parts of the world. However, considerable variation exists among world regions in the extent to which these regions have historically been invaded. Here we compile data on numbers of non-native insects and plants from 44 countries and world regions. We applied structural equation modeling (SEM) to tease out the role of various habitat characteristics on the number of insect invasions. These factors included land area, distance from mainland, latitude, numbers of human occupants, numbers of native plant species and numbers of non-native plant species. The SEM model indicated that the principal driver of insect invasions was plant species richness; the largest effect on number of non-native insect species was number of native and non-native plant species. Habitat features such as land area, latitude and distance from mainland affected insect invasions indirectly by influencing plant diversity. These results shed important new light on the determinants of insect invasions and demonstrate the key role played by plant diversity in facilitation of insect invasions.

world, biological invasion, biogeography, species

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KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3308 **Impacts of forest insects on the carbon cycle and possible mitigation options**

Kurz, W.* (1); Smyth, C. (1); Hafer, M. (1); Neilson, E. (1)

(1) Canadian Forest Service, Natural Resources Canada, Victoria BC, Canada

Abstract: Native and invasive forest insects are increasingly affecting forest health and can have significant impacts on the carbon cycle. In Canada, estimates derived from the National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS) indicate that between 1990 and 2015, 23 Mt C yr^{-1} have been transferred from live biomass to dead organic matter pools as a result of insect-induced mortality. Transfers ranged from below 1 Mt C yr^{-1} to 87 Mt C yr^{-1} during periods of large outbreak events. Additional impacts of insects include reductions in growth rates and Net Primary Productivity of host trees. Both reductions in carbon uptake and increases of carbon release from the decay of killed trees affect carbon fluxes. However, the net impacts on the carbon balance are more difficult to quantify because of potential positive growth responses of non-host trees and understorey stand components, including shrubs, herbs and grasses. With increasing focus on the role of forests in climate change mitigation, the potential responses to future insect outbreaks need to be assessed. Opportunities exist to salvage log insect-killed trees or stands, thus re-directing harvest from healthy growing stands to those adversely affected by insects, with positive impacts on the landscape-level carbon balance. However, lack of road access, the proportion of trees killed in a stand, conditions of remaining stands, and in particular the ability of the remaining (woody) vegetation to respond positively to the reduction in the competition for resources resulting from insect kill can all affect long-term carbon dynamics. Forest management strategies aimed at mitigating the impacts of insects on the carbon balance need to be evaluated using region and site-specific assessments of the consequences of proposed activities. Finally, understanding the impacts of insects on the climate system may also have to consider changes in surface reflectance (albedo), and energy and water balances.

Canada, CBM-CFS3, mitigation options

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-601 **Climate change and wildfire - managing in the face of uncertainty**

Stephens, S.* (1)

(1) ESPM Department, UC Berkeley, Berkeley, United States

Abstract: Early work in the western USA demonstrated the beneficial effects of 'light burning' and wilderness fire management but these ideas were eventually overridden by a full fire exclusion policy. Many western USA forests have therefore been altered by 100 years of fire suppression and past harvesting which has increased their hazards and susceptibility to fires with intensities and severities outside of desired ranges. How fire size, frequency, and severity are being affected by changing climate and past management is a critical issue. We know how to restore frequent fire adapted forests, with generally positive or neutral ecological effects. When discussing current fire impacts it is critical to anchor them to specific fire regimes. Crown-fire-adapted ecosystems are likely at higher risk to climate change influenced fire regimes as compared with other ecosystems once subject to frequent less severe fires. Adaptive strategies to increase forest resilience include resistance options, resilience options, response options, and realignment options. Ideas will be presented that could be used to conserve forests in an era of climate change. The next 2-3 decades are critical in terms of beginning a trajectory of increasing the resilience of forest ecosystems adapted to frequent, low-moderate intensity fire regimes. There are challenges but also great possibilities.

historic variability, restoration, fire management

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3328 **Vulnerability of United States Tree Species to Environmental Disturbance and Change**

Monahan, W.* (1); Krist, F. (1); McMahan, A. (2); Lopez, V. (1); Zweifler, M. (2); Ellenwood, J. (3)

(1) USDA Forest Service, Forest Health Protection, Fort Collins, Colorado, United States; (2) Cherokee Nation Technologies, Fort Collins, Colorado, United States; (3) USDA Forest Service, Inventory, Monitoring, and Assessment Research, Washington, DC, United States

Abstract: Tree species may be especially vulnerable to environmental changes occurring near the margins of their geographic range or ecological niche. This is because marginal populations can be more physiologically stressed, demographically unstable, or susceptible to invasion, compared to core populations. We use distribution models, derived from Forest Inventory and Analysis data, developed for major hardwood and conifer tree species (n = 264) in the contiguous United States and Alaska to assess where and how individual species' distributions are marginal in either geographic or environmental space (< 5th or >95th percentiles). Preliminary results suggest that (1) marginal elevations across tree species are particularly concentrated between 0 and 140 m (< 5th percentile) and 540 and 1300 m (>95th percentile); and (2) the most common dynamic environmental variables affecting tree species' ecological niches are mean temperatures of the coldest and warmest months, growing season precipitation as a fraction of annual precipitation, and soil drainage index. We analyze and report marginal areas and environments for each tree species individually and by guild. We conclude with discussion of how results may be used to characterize the susceptibility and vulnerability of trees to native and non-native forest pests.

forest health, conifers, hardwoods, vulnerability

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IUFRO17-1792 **Carbon Mitigation and Other Ecosystem Services with Wood Products and Forests**

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(1) Yale University, Forestry and Environmental Studies, New Haven,CT, United States; (2) Yale University School of Architecture, Gray Organschi Architecture, New Haven, CT, United States; (3) Gray Organschi Architecture, New Haven, CT, United States; (4) Univ. Washington, School of Environment and Forest Sciences, Seattle, WA, United States; (5) Univ. Washington, School of the Environment and Forestry, Seattle, WA, United States

Abstract: Carbon mitigation in wood products and in ecologically diverse forests can complement each other, exceeding the carbon sequestration in forests or products alone and providing many other ecosystem services. Life cycle analyses show that wood construction avoids the "slow domain" carbon emissions pathways of burning fossil fuels to produce steel, concrete, and brick, thereby avoiding significant carbon emissions with long atmospheric residence times. Forests currently occupy nearly 30% of the world's terrestrial area but only employ 0.4% of the world's workforce. Currently only 20% of global wood growth is being harvested and only 7% used in building, with the rest used for subsistence fuelwood and paper. If all wood growth were used in buildings with residuals and scraps burned for energy, global carbon emissions would be reduced by over 20%. Appropriately managed forests including harvesting wood could restore degraded forests, increase biodiversity, reduce catastrophic forest fires, increase water from forests, and make forests more resilient and responsive to climate change. And, forest employment could increase to 6% of the workforce. Techniques are being developed to plan and monitor sustainable forest management using computer models and satellites.

forest carbon, wood buildings, biodiversity, labor

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1993 **Quantifying forest resilience to disturbance and climate**

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(1) Northern Arizona University, School of Forestry, Flagstaff, United States

Abstract: Ecological resilience is the ability of a system to undergo disturbance without changing functional states. Promoting resilience through management is an important way to ensure that natural systems continue to provide vital ecological services. Resilience has been identified as important in forested ecosystems susceptible to increasingly variable disturbances under climate change, yet it has been rarely quantified. We used metrics of stand structure to quantify the potential resilience of ponderosa pine and dry mixed conifer forests on a forested landscape in northern New Mexico, with respect to fire, insects, and drought on a continuous scale from 1-9. The dry mixed conifer forest type's mean resilience (5.64) was found to be higher than the ponderosa pine type's mean (3.90). We expanded the landscape to the regional scale (Southwestern US) and compared the potential resilience score of a restored ponderosa pine stand to the average score in the ponderosa pine forest type across the Southwest. Nearly 100% of the ponderosa pine forests in the region were potentially less resilient as compared to a restored stand. Land managers can use these results to prioritize stands for treatment based on their potential resilience score and/or their proximity to communities. At the regional scale, this work can be used to monitor the progress and success of forest restoration projects.

fire, insects, drought, landscape restoration

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191 - Nitrogen deposition: spatial-temporal change and ecological impacts

K 1 (Konzerthaus Freiburg)

IUFRO17-427 **Inorganic nitrogen deposition to forest ecosystems in Europe - spatial patterns and temporal changes in the past 15 years**

Schmitz, A.* (1); Hansen, K. (2); Michel, A. (1); Prescher, A.-K. (1); Sanders, T. G. . M. (1); Seidling, W. (1); Clarke, N. (3); Verstraeten, A. (4); Pihl Karlsson, G. (5); Zlindra, D. (6); Vesterdal, L. (7); Benham, S. (8); Elustondo, D. (9); Nicolas, M. (10); Waldner, P. (11)

(1) Thünen Institute of Forest Ecosystems, Eberswalde , Germany; (2) IVL Swedish Environmental Research Institute, Stockholm, Sweden; (3) Norwegian Institute of Bioeconomy Research, Ås, Norway; (4) Research Institute for Nature and Forest (INBO), Brussels, Belgium; (5) IVL Swedish Environmental Research Institute, Göteborg, Sweden; (6) Slovenian Forestry Institute, Ljubljana, Slovenia; (7) University of Copenhagen, Frederiksberg C, Denmark; (8) Forest Research, Farnham, United Kingdom; (9) University of Navarra, Pamplona, Spain; (10) Office national des forêts, Fontainebleau , France; (11) Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland

Abstract: Economic transformation and emission reduction efforts result in ongoing changes in inorganic nitrogen deposition loads to forest ecosystems. Atmospheric deposition to forests across Europe is continuously measured at the intensive forest monitoring (Level II) plots of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests). The sampling design allows the analysis of both, throughfall (under the canopy) and open field deposition. Evaluations of measurements on 101 plots showed that mean throughfall deposition rates of ammonium and nitrate decreased by 9% and 13%, respectively, between the two periods 2000-2004 and 2007-2011. Deposition rates in open field precipitation decreased by 11% and 13% for the same substances between the same periods. This temporal development of deposition rates of inorganic nitrogen compounds is put into context with patterns of the national emission inventories and estimations from spatial transport and deposition models (EMEP). A potential shift toward an increasing relative importance of reduced forms of deposited nitrogen emphasizes the importance of understanding not only the effects of the total amount but also of the form (reduced vs. oxidized) of nitrogen input to forest ecosystems. We will present and discuss the magnitude and spatial pattern of such changes in the deposition of different nitrogen compounds, based on the long-term nitrogen deposition measurements of the ICP Forests Level II network across Europe.

Deposition, Ammonium, Nitrate, ICP-Forests

K 1 (Konzerthaus Freiburg)

IUFRO17-2639 **Response of temperate forest N status to long-term recovery from acidification and decreasing atmospheric N deposition**

Verstraeten, A.* (1); Neirynck, J. (1); Cools, N. (1); Roskams, P. (1); Louette, G. (1); De Neve, S. (2); Sleutel, S. (2)

(1) Research Institute for Nature and Forest (INBO), Brussels, Belgium; (2) University of Ghent, Department of Soil Management, Ghent, Belgium

Abstract: Nitrogen (N) depositions in European forests are decreasing, while there were local signs of initial recovery from acidification during the past three decades, but it is unclear how long N-saturated forests will take to recover. We aimed to test the hypothesis that forest N status in northwest Europe has started to improve. We evaluated the evolution of multiple N saturation indicators in five ICP Forests Level II plots in northern Belgium, using long-term soil solution and foliage datasets (1999-2015):
- Throughfall depositions of dissolved inorganic N decreased by 2.4-5.0% per year.
- The ratio of dissolved organic nitrogen (DON) and total dissolved nitrogen (TDN) in soil solution, DON:TDN increased since 2005 in all plots.
- The ratio of dissolved organic carbon (DOC) and nitrate (NO3-) in soil solution, DOC:NO3- increased since 2002 in four out of five plots.
- The ratio of N and phosphorus (P) in foliage, N:P remained unchanged.
- The ratio of base cations (Bc = calcium + potassium + magnesium) and N in foliage, Bc:N remained unchanged.
Changes in the soil solution chemical composition confirmed an improvement in forest N status, but biotic recovery appeared pending given the constant foliar N:P ratio and Bc:N ratio. This questions if common critical DOC:NO3- limits are stringent enough for European forest soils. Clearly, insight in forest recovery from N saturation requires a multiple indicator approach, and further monitoring of foliar N:P levels alongside these soil processes is needed to monitor the evolution of forest N status.

ICP Forests, monitoring, N saturation

K 1 (Konzerthaus Freiburg)

IUFRO17-404 **Integrating species composition and leaf nitrogen content to indicate effects of nitrogen deposition**

Du, E.* (1)

(1) Beijing Normal University, Peking University, Beijing, China

Abstract: Nitrogen (N) deposition has been enhanced globally and has aroused concerns of its impacts on terrestrial ecosystems. Ecological indicators play an important role in ecosystem monitoring, assessment and management in the context of an anthropogenic transformation of global N cycle. By integrating species composition and leaf N stoichiometry, a new community N indicator was defined and tested in the understory plots of an N enrichment experiment in an old-growth boreal forest in Northeast China. Three-year N additions showed no significant effect on the understory species richness, but obvious shift in species composition occurred. The response of leaf N content to N additions was generally positive but varied by species. Overall, the community N indicator increased significantly with higher N addition level and soil available N content, being in the shape of a non-linear saturation response curve. The results suggest that the community N indicator is an effective tool to indicate changes in ecosystem N availability and critical values of the community N indicator for specific vegetation type can provide useful information for nature conservation managers and policy makers.

ecological indicator; nitrogen deposition;

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208 - Social and Economic dimensions of forest health: Contributing to a biosecure future

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-901 **Investigating the public response and risk perceptions in relation to tree pest and disease outbreaks in the UK**

Urquhart, J.* (1); Potter, C. (1); Barnett, J. (2); Fellenor, J. (2); Mumford, J. (1); Quine, C. (3)

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Abstract: Invasive tree pests and diseases present a significant risk to tree health, plant biosecurity and ecosystem functions. Outbreaks often involve complex interactions between attempts by governments to manage risks, media coverage of the threat and variable degrees of stakeholder and public attention. The difficulty for policymakers is that the technical risk assessment tools they typically rely on to set priorities and recommend preventative actions may not always be well attuned to evolving public risk understandings and the social and cultural processes which shape these. Drawing on the Social Amplification of Risk Framework (SARF), the UNPICK project explored how risk is communicated, interpreted and acted on by publics and local stakeholders over the course of pest and disease outbreaks. In this paper, we present findings from a national survey of the UK public designed to gauge awareness and concern about tree pests and diseases and to assess willingness to adopt more biosecure behaviours. The results suggest that, despite low levels of awareness and knowledge, there is concern about tree health and some willingness to make behavioural changes. When cross-tabulated with a survey undertaken three years ago, analysis suggests that awareness and concern about tree health issues and a willingness to adopt biosecure behaviours has declined between 2013 and 2016. To supplement the survey findings, qualitative research was undertaken for two outbreak case studies: (Hymenoscyphus fraxineus (ash dieback) and Thaumetopoea processionea (oak processionary moth)). Through semi-structured interviews and Q Methodology we assessed the way in which local publics perceive, experience and interpret tree health risks and explored ways of engaging and communicating with these publics about current and likely future tree health risks. The paper presents findings from this comparative analysis.

public perceptions; SARF; ash dieback; OPM

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3134 **Socio economic implications of Forest pest outbreaks in developing and countries with economies in transition**

SATHYAPALA, S.* (1)

(1) Food and Agriculture Organization of the United Nations , Rome , Italy

Abstract: Forests fulfil an array of important ecological, economic and social functions.Globally many communities depend on Forest products such as timber, fuelwood, fibre and non-wood forest products (food, medicine, homey), and ecosystem services such as recreation, watershed protection, wildlife habitat, and grazing for livestock.
Increasing travel and trade coupled with climate change have increased the incidence of forest pests and diseases worldwide. To identify the full impact of their occurrence in forest ecosystems, an understanding is needed not only of the direct biological and economic impact, but also of the social sciences, and the underlying socio-economic as well as cultural aspects.
Based on the results of Technical Cooperation Projects led by FAO, the author discusses three case studies of forest pest outbreaks in developing countries and those countries with transitioning economies to demonstrate how degradation of forest health impacts on the livelihood of local communities. Further the presentation discusses lack of the appropriate methodologies to measure the social and cultural impact of forest pest outbreaks and how governance issues lead to forest degradation and poor implementation of sustainable forest management practices.
In seeking solution the author emphasis the possible use of pilot studies to measure social and cultural impacts and role of forest governance and the significance of inclusion of forest dependent communities in implementing forest health management strategies.

socio- economic, pest outbreaks,

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1626 **Improving risk communication and engagement within biosecurity agencies**

Allen, W.* (1); Grant, A. (2); Langer, E.R. . (. (2); Marzano, M. (3); Ogilvie, S. (4); Mark-Shadbolt, M. (5); Waipara, N. (6)

(1) Learning for Sustainability, Christchurch 8244, New Zealand; (2) Scion, Christchurch, New Zealand; (3) Forest Research, Midlothian, United Kingdom; (4) Eco Research Associates Limited, Christchurch, New Zealand; (5) Lincoln University, Lincoln, New Zealand; (6) Auckland Council, Auckland, New Zealand

Abstract: New Zealand's forest conservation estate and primary production sectors are at risk from exotic plant pests (insects and pathogens) which are escalating alongside the expansion of trade and tourism industries. A growing challenge for biosecurity management is to manage two-way risk communication and engagement (RC&E) strategies that account for community perspectives. Recent research highlights that agencies must step beyond a narrow operational focus to engage more meaningfully with stakeholders and enter into dialogue based on participation, trust and understanding. Although these needs are known, there are a lack of methodologies and tools to undertake this engagement and support community preparedness and action. A key focus has been to develop means for appreciating and improving agency-community engagement and operational outcomes. By using a Participatory Action Research (PAR) approach with agencies, we are building skills and pathways to help agencies to assess and adapt their risk communication and engagement approaches - taking particular account of Maori (the indigenous people of New Zealand) - to aid future response processes. This work highlights that RC&E can be seen to occur within a broad framing of 'wartime' and 'peacetime'. Performance rubrics and outcomes models are being used to co-develop situated awareness of risk communication and engagement with agencies for assessing and improving individual operational systems. By clarifying the nuanced nature of RC&E we contribute a better understanding for integrating diverse operational knowledge and need to support agency-community engagement within biosecurity.

Risk communication and engagement; rubrics

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208 - Social and Economic dimensions of forest health: Contributing to a biosecure future

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-317 **Are we ready/able to protect urban trees?**

Jones, G.* (1); Stokes, J. (2)

(1) Fera, York, United Kingdom; (2) The Tree Council, London, United Kingdom

Abstract: If we want to plant more trees the follow on work from the National Ecosystem Assessment suggested that they should be closer to population centres in order to increase their value to society. If trees close to people are more valuable to us, this begs the question, 'How we look after them, to ensure that these values continue to flow, at least cost?'
Management of urban trees is complex, with many different tree owners taking differing views of their responsibilities. It is likely that the value of urban trees only plays a superficial part in their decision making about their tree management, since most of the values are hidden (i.e. not priced in markets). However, the value of urban trees and how to manage them has come to the fore with the spread of Ash Dieback, and tree health is beginning to enter the decision making agenda.
The situation is further complicated, as the flow of values from the trees are at risk from a range of new pests and diseases, at a time when those responsible for their management are stretched financially. These stretched budgets and diffuse responsibilities for tree management, suggest that combining resources and working over wider spatial area could be beneficial to many stakeholders, but how can this be achieved?
In this paper we report on research into urban tree health governance that is part of Defra's Future Proofing Plant Health programme. This will include an early look at results on governance, finance, and procurement issues as well as the tools that urban tree and infrastructure managers require to move from a reactive-tactical approach to tree health to a proactive-strategic approach.

Governance, finance, procurement, biosecurity

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3073 **Societal costs of urban tree diseases**

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Abstract: Diseases of tree species commonly planted in urban areas are spreading rapidly. Rather than effects on wood production, which still tend to dominate the economics of forests, those on non-market benefits to society dominate evaluation of urban tree resources. While there are established techniques for valuing carbon fixing by plantation crops, the needed physical yield models for open-grown urban trees are not available, and "reasonable assumptions" must be made before the contentious techniques of carbon pricing can be deployed. Physical impacts on hydrological and air conditioning services have been evaluated, though location-specific data are hard to acquire. Several approaches to valuing aesthetic effects, and many variants of them, have been applied: the CTLA method, the Helliwell method, and methods reliant on mainstream valuation of ecosystem services such as hedonic pricing. Application to typical urban tree situations in the UK shows that the results are in disagreement. Taking the most realistic methods and results, it seems that effects on aesthetics and carbon transactions are the most serious results of urban tree diseases.

tree disease, urban trees, ecosystem services

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-462 **Plants, pathology and practice: bridging the gap between knowledge and action in UK nurseries**

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Abstract: It is widely acknowledged that a major threat to tree health biosecurity comes from trade, particularly through the importation of live plants, containers and growing mediums. Nurseries can collectively play a key role in mitigating pest and diseases through attention to their daily practices (e.g. procuring plants; storage and management). More widespread adoption of best practice in the sector could be promoted through the introduction of a UK-wide accreditation scheme. However, the success of such a scheme would depend not only on its uptake by nurseries but also consumer behaviour. To date the relationships between consumers and nurseries, as well as the sensitivity of nurseries to public opinion have remained under researched. Here we draw on qualitative results to assess the appetite for accreditation amongst UK nurseries. Secondly, we begin to consider which factors influence the purchasing habits of landscapers, gardeners and woodland owners. As part of this inquiry we provide findings from a UK-wide attitudes survey designed to elicit the public's plant buying habits and perceptions around accreditation. As a key challenge of accreditation is likely to be the cost of new biosecurity measures, we also explore consumer willingness to pay extra or travel further to buy accredited products.

Nurseries, accreditation, consumer attitudes

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5 - Open Session

K 8 (Konzerthaus Freiburg)

IUFRO17-1477 **Botryosphaeriaceae species composition on native Melastomataceae (Myrtales) shrubs in South Africa and Southern China**

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Abstract: The Botryosphaeriaceae are common endophytes and latent pathogens of woody plants worldwide, including trees in the Myrtales. While these fungi are commonly found on trees in the Myrtaceae and Combretaceae, little is known regarding their presence in other families of the Myrtales. Botryosphaeriaceae species were collected from three Melastomataceae shrubs, Melastoma sanguineum and M. candidum, native and sympatric in Southern China, and Dissotis canescens, native in South Africa. Isolates were identified based on phylogenetic analyses of ITS rDNA, β### -tubulin and RPB2 sequences. Nine phylogenetically distinct groups were recognized residing in the genera Botryosphaeria, Neofusicoccum and Lasiodiplodia. They were identified as B. ramosa, N. mangiferae, N. parvum, L. gonubiensis, L. lignicola, L. pseudotheobromae, L. theobromae, and two unknown Lasiodiplodia species. Botryosphaeriaceae species composition differed significantly between the two regions, and only L. gonubiensis and L. theobromae overlapped between all hosts and regions. Lasiodiplodia species were dominant on the two hosts in Southern China, and most of the species co-occurred on both hosts where they grow sympatrically. In contrast, Lasiodiplodia spp. were identified only occasionally on D. canescens in South Africa, while N. parvum was dominant and represented over 90% of isolates in South Africa and was absent from the hosts in China.

Neofusicoccum, Lasiodiplodia, native hosts

K 8 (Konzerthaus Freiburg)

IUFRO17-1299 **Management strategies for biological control: Utilising DNA barcoding to increase diversity and abundance of Diptera and Hymenoptera.**

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Abstract: Using parasitoids to control species that can potentially cause damage to agriculture and forestry has gained interest in recent times. With parasitic Hymenoptera and Diptera being of particular interest. These species are usually focused and highly efficient at finding their hosts. Consequently, parasitoids are able to respond to increases in host numbers rapidly, and in many cases bring host populations back to stable numbers, thus reducing the potential for extensive crop damage. By adjusting management practice in and around crop areas, particularly in forestry, a higher diversity and abundance of parasitoids, capable of effective pest control, can often be sustained.

For these reasons they are one potential strategy being examined to control potential future outbreaks of pine tree lappet moth (Dendrolimus pini) in Scotland. The species was only found breeding in Scotland in 2009 and there is still uncertainty as to whether it is a native or introduced species. However, it could potentially pose a threat to Scottish forestry especially under future climate scenarios.

There is many successful strategies to collect these groups of parasitoids but they can prove much harder to identify. Often requiring expert assistance and can be very time consuming. This can make identifying large numbers of specimen's accurately difficult. However the development of the ease in which, DNA barcoding can be carried out offers an easy solution.

In this study species of parasitoid known to use D.pini were listed from host catalogues and other literature. It allowed the number of these species with DNA barcodes to be assessed, and those without to be listed to look for specimens for barcode extraction. Specimens from field trapping were then sequenced and identified allowing presence of D.pini parasitoids to be confirmed. Investigations were then carried out into how different forest management strategies could influence abundance of these potential parasitoid biological controls.

Biological Control, Natural Enemies, DNA Barcoding

K 8 (Konzerthaus Freiburg)

IUFRO17-1258 **Comparison of the Botryosphaeriaceae on Acacia koa and A. heterophylla: Evidence of a long-standing separation of two genetically close, but geographically isolated, tree populations**

Jami, F.* (1); Marincowitz, S. (1); Crous, P. W. (2); Slippers, B. (1); Le Roux4, J. J. (3); Richardson, D. M. (3); Wingfield, M. W. (1)

(1) Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Pretoria, South Africa; (2) Westerdijk Fungal Biodiversity Centre , Utrecht, Netherlands; (3) Department of Botany & Zoology, Centre for Invasion Biology, Stellenbosch, South Africa

Abstract: Acacia koa and A. heterophylla are commonly occurring native trees on the islands of Hawaii and La Reunion respectively. An important recent study by Le Roux et al., (New Phytologist, 204.1: 230-242; 2014) has suggested that these trees are, based on phylogeny, the same species, separated geographically more than 1.4 million years ago. An intriguing question is whether their microbiota could in some way reflect their genetic origins. In this study we compared the fungi in the Botryosphaeriaceae in samples from these trees. This was specifically because these fungi are common endophytes in woody plants and they are known to provide an indication of trees being native or introduced into new environments. Isolates were identified based on comparisons of sequence data for the rDNA-ITS, LSU, EF1-alpha and beta-tubulin loci. In total, nine Botryosphaeriaceae species were identified of which four each were specific to samples from Hawaii and La Reunion, with one species common to both islands. The common species, Neofusicoccum parvum, is known to have a wide global distribution and the overall results suggest that A. koa and A. heterophylla have unique fungal biota in the areas where they occur naturally. Although the trees are genetically very similar (A. heterophylla renders A. koa paraphyletic), the results of this preliminary study suggest that they have established unique and independent microbiota. This would reflect a relatively long period of geographic separation.

Botryosphaeriaceae, Acacia, Hawaii, La Reunion

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K 8 (Konzerthaus Freiburg)

IUFRO17-1463 **First results of model development for risk assessment of oak processionary moth (Thaumetopoea processionea L.)**

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Abstract: The growing presence of oak processionary moth (OPM), Thaumetopoea processionea L. (Lep., Thaumetopoeidae), in Central Europe since the 1990s and concomitant consequences for host trees' vitality and human health urgently require hazard control proceedings. With regard to climate change, increased intensities of oak forest defoliation and human infections with urticating hairs (setae) released by the caterpillars are expected.
To evaluate the associated risks for forests and human health, we develop the basic elements of an early warning system which include our findings on regional development conditions (phenology) of OPM and the correlation between its population density and airborne setae concentrations depending on spatial distance and weather conditions.
In this way, our results will serve as decision support for an appropriate and effective application of preventive and regulatory measures in terms of using plant protection products and biocides for the whole range of OPM.

Oak processionary moth, risk, health, defoliation

K 8 (Konzerthaus Freiburg)

IUFRO17-1439 **The effect of Amylostereum spp. on Forest Health in Alabama**

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Abstract: Sirex noctilio is a species of woodwasp native to Europe that has been identified as invasive in Australia, South Africa, and the Northeastern United States. Females cause damage to Pinus spp. by drilling into the xylem to oviposit eggs, venom, and a mutualistic fungus, causing trees to begin to die within days of inoculation. A native species, Sirex nigricornis, has been documented throughout the southeast, but is not believed to cause mortality like the closely related S. noctilio. Certain chemicals emitted by stressed pines have been observed to serve as chemical attractants to the wasps. As a means of exploring pine resistance to Sirex associated fungi, the effect of these mentioned host plant secondary metabolites on the growth of these fungi were tested. Eighteen isolates of Amylostereum spp. collected worldwide were grown in saturated atmospheres or in direct contact with pure monoterpenes for 7 days. Fungal growth in the saturated atmosphere was measured on day 7 while the tactile experiment was measured at 3, 5, and 7 days. These experiments showed that certain metabolites such as 4AA, Alpha-Phellandrene, (+) Camphene, and (-) Limonene were shown to significantly reduce growth of isolates compared to control treatments. Conversely, Alpha-Pinene and Beta-Pinene treatments tended to increase growth rates of the fungal isolates. A difference in growth rates between isolates from the northern hemisphere and southern hemisphere was also observed. The treatments (+) Alpha- Pinene and Beta-Myrcene resulted in the highest percentage of fungal growth for all isolates tested when comparing fungal growth as a percent area relative to the controls.

K 8 (Konzerthaus Freiburg)

IUFRO17-1500 **Genetic and physiological response of Scots pine saplings to artificial inoculation with Sphaeropsis sapinea, the pathogen causing Diplodia tip blight**

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(1) Forest Research Institute of Baden-Württemberg, Department of Forest Protection, Freiburg, Germany; (2) Georg-August-University of Göttingen, Büsgen Institute, Göttingen, Germany; (3) Albert Ludwig University of Freiburg, Chair of Tree Physiology, Freiburg, Germany

Abstract: Diplodia tip blight of pine, caused by the thermophilic microfungus *Sphaeropsis sapinea*, has developed into an increasing problem impairing growth and health of native Scots pine (*Pinus sylvestris* L.) forest in Germany. It has been shown that different provenances of Scots pine originating from Germany differ in susceptibility to *S. sapinea*. In the framework of the BMBF government-funded joint research project WAHYKLAS, we aim to determine the differences in susceptibility of Scots pines to *S. sapinea* at provenance or genotype level by performing molecular biological and physiological analyses. In a common garden trial, *Pinus sylvestris* saplings from two provenances (Nordostdeutsches Tiefland and Oberrheinebene) were inoculated with a mycelial suspension of *S. sapinea*. Symptoms of infection were clearly visible on needles one week after inoculation. At this time point (light infection) and after two additional weeks of exposure (severe infection), the genetic and physiological responses of the pine saplings to *S. sapinea* infection were investigated. The genetic response was initially also investigated at more frequent time points. The response of the saplings to infection was compared with untreated and mock-inoculated controls. The results of this experiment are presented.

pine, Diplodia infection, host defense response

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5 - Open Session

K 8 (Konzerthaus Freiburg)

IUFRO17-292 **Ecological and Economic Impact of Caliciopsis pinea on Pinus strobus in New England, U.S.A.**

Costanza, K.* (1); Livingston, W. (1); Munck, I. (2); Lombard, K. (3); Fraver, S. (1); Rice, R. (1)

(1) University of Maine, School of Forest Resources, Orono, United States; (2) USDA Forest Service, Northeastern Area State and Private Forestry, Durham, United States; (3) New Hamshire Division of Forests and Lands, Concord, United States

Abstract: Eastern white pine (Pinus strobus) is a signature species in eastern North America at an ecological, historical, and economic level. However, white pine has experienced unprecedented damage in recent years due to native pathogens. One increasing concern is Caliciopsis pinea, a native fungus that can result in thinner tree canopies, profuse resin secretions, and reduced wood quality. Caliciopsis represents a serious emerging threat, possibly associated with climate change, however its impact on pine remains poorly understood. Consequently, our research team (1) intensively sampled 36 trees; (2) harvested an additional 60 trees for lumber; and (3) collected infected pine tissue from both thinned and unthinned sites.
DNA analysis confirmed Caliciopsis was present in all stands, and associated with symptomatic damage. However, a wide range of fungal species were isolated from necrotic tissue associated with C. pinea damage. Caliciopsis was the only species cultured that is a known pathogen of white pine. Results from our lumber study indicate that 28-38% of pine sawlogs had C. pinea, but only 7.5-12.5% of sawlogs had a loss in quality and economic value due to the pathogen. By understanding the extent to which Caliciopsis reduces white pine growth, increases mortality risk, and reduces wood value, our research can guide management prescriptions aimed at mitigating future damage.

pathogen-native, forest products, climate change

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86 - The science of tree health and how we can: Multidisciplinary research from the Tree Health and Plant

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3613 **Managing trees for resilience to multiple threats: the importance of diversity and adaptation to tree health.**

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(1) Centre for Ecology and Hydrology, CEH, Penicuik, United Kingdom; (2) RBGE, University of Edinburgh, Forest Research, University of Aberdeen, Scotland's Rural College, Scotland, United Kingdom

Abstract: Trees challenged by new pests and pathogens rarely face a single threat organism and are likely to be dealing with the additional test of climate change at the same time. In addition, human modification of forest habitat, managed planting and interruption of population dynamics have altered forest landscapes and hampered their ability to respond to change. At the same time, given the rate of increase of new pests and pathogens for many tree species, it is unlikely to be logistically or economically feasible to tackle each new threat one at a time. If we are to ensure resilience of our forests, we must accept the reality of multiple threats and find better ways to harness and make use of the extensive genetic diversity within tree species, promote adaptive processes (natural or managed), and minimise changes to the landscape that accelerate threats to tree health.

Genetic diversity, pests and pathogens, resilience

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1714 **Multiple origins of the Dothistroma outbreak on pine species in Scotland**

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(1) Institute of Evolutionary Biology, University of Edinburgh, Edinburgh, United Kingdom; (2) Scotland's Rural College, Edinburgh, United Kingdom

Abstract: Since the late 2000s Dothistroma outbreaks causing serious damage have been reported on plantations of Scots, Corsican and lodgepole pine in Scotland. Of particular concern has been the recent discovery of Dothistroma on native Scots pine in the Caledonian pinewoods, a community that is of high conservation value. To determine the origin(s) of these outbreaks Dothistroma isolates were sampled from plantations of all three pine species, from seven Caledonian pine populations and from forest nurseries supplying pine transplants. Isolates were scored for their genotype at eleven polymorphic microsatellite loci. Cluster analysis revealed three distinct races; a race with high genetic diversity and equal frequencies of mating types that is apparently spreading north from England; a race with moderate diversity and a low frequency of mating type 1 likely to be endemic on Caledonian pine; a race of very low diversity, lacking mating type 1, confined to lodgepole pine that has probably been introduced from North America. Analysis of the races in culture show that they differ significantly in growth rate at different temperatures. The implication of these results for management of Dothistroma in the U.K. will be discussed.

Dothistroma, race, microsatellite

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3816 **Genetic variation for susceptibility to Dothistroma septosporum in Scottish Scots pine (Pinus sylvestris)**

Perry, A. (1); Cavers, S.* (1); Cottrell, J. (2); Ennos, R. (3); Brown, A. V. (4)

(1) Centre for Ecology and Hydrology, CEH, Penicuik, United Kingdom; (2) Forest Research, Roslin, United Kingdom; (3) University of Edinburgh, Edinburgh, United Kingdom; (4) Forestry Commission, Edinburgh, United Kingdom

Abstract: Scots pine, one of only 3 conifer trees native to Britain, is threatened by a serious fungal disease, Dothistroma needle blight (DNB). As well as having potential impacts for the forest industry through lost productivity, there is concern that the disease may affect the remaining fragments of indigenous native pine forest in northern Scotland. To evaluate the capacity of these pinewoods to respond to the threat posed by DNB, we conducted provenance-progeny tests of Scots pine sourced from native pinewoods and inoculated with the pathogen. Tests under controlled conditions using a single isolate of the pathogen made clear that there was considerable natural variation in the host for susceptibility even under heavy pathogen pressure. Tests conducted in field conditions with natural inoculation by the pathogen indicated geographic variation in susceptibility, with Scots pine provenances from milder, wetter sites being less susceptible. The latter suggests that the host may have co-evolved in situ with the pathogen in milder, wetter sites for some time. These findings give cause for optimism that the remnant native pinewoods may have capacity to adapt to the threat, given appropriate management.

Dothistroma needle blight, genetic diversity

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-199 **The tree microbiome as part of the extended phenotype**

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Abstract: The impact of micro-organisms within host plant tissues ranges from mutualistic to pathogenic. Recent literature also discusses the role of endophytes as modifiers of plant disease. While there is evidence in some studies to suggest that endophytes might behave as enablers to pathogens, much literature emphasises the potential that endophytic microbial communities might have in suppressing and/or controlling pathogens within the community, while being adaptable over short periods of time.
To date studies demonstrating control of pathogens within the microbial community are scarce and variation in microbial community structures at geographic scales and in relation to tree local adaptation is poorly understood. Trees, however, are the environment in which the endophyte community assembles and it stands to argue that heritable traits in the tree phenotype are reflected in the microbial communities they maintain. Here we present the results of a study of Scots Pine asking how effective trees are as ecological filters in determining the structure of their fungal endophyte community. We discuss what potential role the management of endophyte communities could have to mitigate threats from disease particularly in a fast changing environment.

tree health, fungal endophytes, community genetics

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Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1382 **Genomics of Fraxinus (Oleaceae); a genus under severe threat**

Kelly, L.* (1); Lee, S. (2); Sykes, R. (2); Koch, J. (3); Carey, D. (3); Jepson, P. (4); Carlson, J. (5); Rossiter, S. (1); Crowther, W. (1); Crowther, W. (6); Buggs, R. (1); Buggs, R. (7)

(1) School of Biological and Chemical Sciences, Queen Mary University of London, London, United Kingdom; (2) Forest Research, Northern Research Station, Midlothian, United Kingdom; (3) U.S.D.A. Forest Service, Delaware, United States; (4) School of Geography and the Environment, Oxford, United Kingdom; (5) Department of Ecosystem Science and Management, Pennsylvania State University, University Park, United States; (6) School of Life Sciences, The University of Warwick, Coventry, United Kingdom; (7) Jodrell Laboratory, Royal Botanic Gardens, Kew, Richmond, United Kingdom

Abstract: *Fraxinus* (Oleaceae; olive family) is a genus of c. 48 tree and shrub species, including taxa of ecological and economic importance. *Fraxinus* species face severe threats from an invasive beetle species (emerald ash borer, EAB) in North America and a disease caused by an invasive fungal pathogen (ash dieback, ADB) in Europe. In this project, we have aimed to develop a new approach for identifying genes conferring resistance or tolerance to tree pests and pathogens based on detecting evidence of convergent molecular evolution from whole genome sequences in species with reduced susceptibility to ADB and EAB. In order to screen for genome-wide evidence of convergent molecular evolution, we have conducted whole genome sequencing (WGS) for 34 individuals from 31 *Fraxinus* species, representing all of the sections within the genus. Using a combination of de novo assembly, mapping and variant calling, we are analysing a reference set of c. 39,000 genes identified from the *F. excelsior* genome (www.ashgenome.org) across the genus. In this talk, we will outline the latest results from our analyses of molecular convergence and efforts to identify candidate genes with potential roles in resistance or tolerance to ADB and EAB.

Ash dieback; Fraxinus; emerald ash borer; genomics

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-900 **Tree pests and diseases and the social amplification of risk: an analysis of expert, policy and stakeholder risk perceptions**

Potter, C.* (1); Urquhart, J. (1); Barnett, J. (2); Fellenor, J. (2); Mumford, J. (1); Quine, C. (3)

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Abstract: The growing exposure of trees, woods and forests to invasive tree pests and diseases means that experts, policy makers and stakeholders increasingly find themselves having to assess often rapidly evolving risk events. Tree pest and disease outbreaks are often fraught with uncertainty, both in terms of the available scientific evidence, which often emerges only as outbreaks unfold, and the potential impacts and future trajectories of the pest or disease. By applying the Social Amplification of Risk Framework (SARF), this paper draws on a documentary analysis and 52 key informant interviews to examine how experts, stakeholders and policymakers in the UK have dealt with the risks to tree health posed by Phytophthora ramorum, oak processionary moth (Thaumetopoea processionea) and Chalara ash dieback (Hymenoscyphus fraxineus). By challenging the notion of an objective expert construction of risk, this paper explores the social, psychological, institutional and cultural filters through which experts and key stakeholders frame their risk understandings. Our findings suggest that, in the face of uncertainty, it is difficult for experts and stakeholders to make objective assessments based on technical evidence alone. Rather, they draw on a wide range of information sources and networks, along with personal experience and referencing back to previous risk events, in order to construct their own risk understandings. An implication of this is that lay publics and the news media can act as 'amplifiers' of risk, causing a response and ripple effects in the institutions managing and regulating outbreaks. The latter are found to be responding both to the hazard event itself but also to second order, or reputational risks, reflected in what they attribute as public concern. The implications of these findings for tree health policy, management and risk communication are discussed.

tree health; risk perception; uncertainty

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165 - Dothistroma and other needle diseases of pine

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3316 **Global geographic distribution of Dothistroma species and the population structure of D. septosporum in northern Europe and Asia**

Drenkhan, R.* (1); Adamson, K. (1); Solheim, H. (2); Barnes, I. (3); Mullett, M. (4); Tomesova-Haataja, V. (5)

(1) Estonian University of Life Sciences , Tartu, Estonia; (2) Norwegian Institute of Bioeconomy Research, Ås, Norway; (3) FABI, University of Pretoria, Pretoria, South Africa; (4) Forest Research, Farnham, United Kingdom; (5) Mendel University, Brno, Czech Republic

Abstract: Dothistroma needle blight (DNB) is one of the most important diseases of pines. The disease has increased in prevalence and severity in areas of the Northern Hemisphere, including Europe, during the last two decades. Importantly, the recognition that two species, Dothistroma septosporum and D. pini, cause DNB emerged relatively recently in 2004. These two species are morphologically very similar, and thus most records prior to 2004 are inconclusive as to which species was causing DNB in various countries and on different hosts. The first objective of this study was to collate detailed records of DNB from 62 countries obtained during the DIAROD COST Action into a central database and then to chart the current global distribution of both pathogens (http://arcgis.mendelu.cz/monitoring/). In all cases, pathogen identity was confirmed using molecular methods. The data shows that DNB has been reported from 76 countries, with D. septosporum confirmed to occur in 44 countries and D. pini in 13. D. septosporum has a wider geographic distribution than D. pini and is the only species reported in northern Europe and Asia. The genetic variability of the pathogen populations in both these areas are unknown. The second aim of this study was to determine the genetic diversity, population structure and migration patterns of D. septosporum from the Atlantic coast of Norway to the Pacific coast of Far East Russia. In total, 238 Eurasian isolates from 12 countries, including 17 populations were analysed with 11 microsatellite markers. Preliminary results indicate that northern European populations are highly diverse compared to those from Far East Russia and Bhutan and that migration of D. septosporum into Asia is most likely to have occurred.

invasive species; genetic diversity; DIAROD

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3486 **Climatic influence on recent outbreaks of Dothistroma septosporum and other needle diseases of pine in Sweden.**

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(1) Swedish University of Agricultural Sciences, Department of Forest Mycology and Plant Pathology, Uppsala, Sweden

Abstract: Climatic envelope modelling indicates that several fungal species that are known to infect pine needle and shoots are likely to experience more conducive conditions in the future in Northern Europe. During the last two decades, Dothistroma septosporum and Diplodia pinea have both been observed for the first time in Sweden. Also, at least four different Lophodermium spp. that differ markedly in their geographic distribution have been detected in the country. The prediction is that we are observing an ongoing range expansion for several of the species in response to climate change. The susceptibility of host is likely to be coupled not only to the presence of new fungal species but also to phenology of the host. However, for each pathosystem not only the long term climatic changes but also year to year variation in weather is important for disease dynamics. This is illustrated by large scale outbreaks of Gremmeniella abietina during the last 60 years in Sweden, where the actual outbreak of acute disease epidemics was triggered by specific weather conditions that allow for build-up of massive spore inoculum.

Climate change, Diplodia, Gremmeniella

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2014 **Dothistroma needle blight management and control**

Bulman, L.* (1); Bradshaw, R. (2); Tubby, K. (3); Fraser, S. (4); Martín García, J. (5); Barnes, I. (4); Musolin, D. (6); La Porta, N. (7); Woods, A. (8)

(1) Scion, Rotorua, New Zealand; (2) Massey University, Palmerston North, New Zealand; (3) Forest Research, Farnham, United Kingdom; (4) Forestry and Agricultural Biotechnology Institute (FABI), Pretoria, South Africa; (5) University of Valladolid-INIA, Palencia, Spain; (6) Saint Petersburg State Forest Technical University, Saint Petersburg, Russian Federation; (7) 8IASMA Research and Innovation Centre, Trento, Italy; (8) British Columbia Ministry of Forests, Smithers, Canada

Abstract: Dothistroma needle blight (DNB) is a disease that is caused by Dothistroma septosporum and D. pini. The disease causes damage of Pinus in many countries and has led to the abandonment of planting susceptible Pinus species in parts of Africa, Asia, Australasia, Europe and North America. The disease can be controlled using a variety of different methods and copper fungicide applications remains the most effective control strategy. Globally, however, this chemical is only routinely applied in forests in New Zealand and Australia. Other management tactics aimed at making conditions less favourable for disease development, such as thinning or pruning, may be effective on some, but not all, sites. Disease avoidance, by planting non-susceptible species, is the most common form of management in Europe, along with deployment of hosts with strong disease resistance. One or both of the Dothistroma pathogens are present almost everywhere Pinus is grown, but it is important that introductions of new haplotypes are avoided. Efforts to exclude new introductions of Dothistroma serves as a model for management of all damaging forest pathogens, where 'whole of system' collaborative programmes and legislation are needed.

Dothistroma, management, biosecurity

All Division 7 (Forest Health) Meeting

165 - Dothistroma and other needle diseases of pine

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1476 **Dothistroma needle blight in Alberta, Canada**

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(1) Canadian Forest Service, Northern Forestry Centre, Edmonton, Canada

Abstract: Dothistroma needle blight has been recorded in Alberta in Canadian Plant Disease Survey reports from the late 1990s on lodgepole pine (Pinus contorta var. contorta Dougl. ex Loud.), Scots pine (Pinus sylvestris L.) and "pine". The pathogen has also been recorded on jack pine (Pinus banksiana Lamb.) in Newfoundland and Ontario by the Canadian Forest Insect and Disease Survey, as well as in the Czech Republic, but its status on jack pine in Alberta is unknown. Recently, the pathogen has been identified as infecting lodgepole pine in Alberta; however, the risk to jack pine in the boreal forest has not been assessed. We are currently conducting experiments under controlled conditions to confirm Koch's postulates on jack pine and we have also developed a LAMP assay that will allow us to identify the pathogen within infected pine needles during field surveys. Through these experiments and upcoming survey activity we are hoping to have a much clearer picture of the risk posed by D. septosporum to P. banksiana in Alberta and the broader boreal forest.

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1872 **The hosts of Dothistroma pini and D. septosporum: their resistance and susceptibility**

Fraser, S.* (1); Barnes, I. (2); Bradshaw, R. (3); Brown, A. (4); Drenkhan, R. (5); Wingfield, M. (1); Woodward, S. (6)

(1) Department of Plant and Soil Sciences, Forestry and Agricultural Biotechnology Institute (FABI), Pretoria, South Africa; (2) Department of Genetics, Forestry and Agricultural Biotechnology Institute (FABI), Pretoria, South Africa; (3) Bio-Protection Research Centre, Institute of Fundamental Sciences, Palmerston North, New Zealand; (4) Forestry Commission Scotland, Silvan House, Edinburgh, United Kingdom; (5) Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Tartu, Estonia; (6) University of Aberdeen, Institute of Biological and Environmental Sciences, Aberdeen, United Kingdom

Abstract: The output of DIAROD working group 3 "the host: resistance and susceptibility", includes an updated host list for the *Dothistroma* pathogens, as well as reviews on within- and between-species variation in susceptibility and the resistance mechanisms involved in this host-pathogen system. *Dothistroma* species have 109 known host species within the Pinaceae, 14 of which were reported after 2008. Twenty host species are rated as highly susceptible, 20 as moderately susceptible and 33 as slightly susceptible. Eighteen species have unknown susceptibility and 18 are in more than one susceptibility category. Between-provenance variation in susceptibility has been reported in 10 species. Although it is difficult to draw many generalisations, it is clear that most DNB outbreaks in Europe have occurred on *Pinus nigra* (including subspecies) and that this host appears to be more susceptible than *P. sylvestris*. It is unclear whether the recent increase in the number of known hosts represents a recent host range expansion, linked to the anthropogenic transfer of *Dothistroma* species or climate change, or is a result of increased awareness of DNB and more widespread disease surveys. This will be discussed further, as will the possible reasons for inconsistencies in the ranking of species and the importance of further research on resistance mechanisms in this system.

collaboration, disease triangle, local adaptation

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-879 **Dynamics of pine pathogens in Switzerland: analysis of 64 years diagnostics**

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(1) Swiss Federal Research Institute, Birmensdorf, Switzerland

Abstract: Pine trees are distributed worldwide and represent important ecological as well as economical players in forests. However, pine trees suffer from numerous pathogens that reduce their growth rates or even threatens their survival. Some of these pathogens have a quarantine status in Europe like for example the pine pith canker caused by Giberella circinata or the Dothistroma needle blight (Dothistroma septosporum and pini). Some others are not under quarantine but can be quite aggressive under climate change conditions like for example the Diplodia tip blight (Diplodia pinea) leading to huge losses in Pinus nigra stands in combination with severe drought.
A huge data collection of over 60 years tree disease diagnostics in Switzerland enables an overview of the dynamics of pine diseases over time. Out of more than 1000 records, first occurrence and abundance evolution of different pine pathogens is addressed in this study. Diplodia tip blight was for example first observed 1986 in urban area around Basel and its frequency increased dramatically these last years. The most commonly diagnosed pine diseases in Switzerland are brow spot needle blight, Dothistroma needle blight, Diplodia tip blight, Scots pine blister rust, Cenangium pine dieback and Lophodermium needle cast.

Dothistroma, Diplodia, tree diseases, abundance

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165 - Dothistroma and other needle diseases of pine

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1002 **Uncovering the role of secreted proteins in the Dothistroma - pine interaction**

Hunziker, L.* (1); McDougal, R. (2); Mesarich, C. (3); Bradshaw, R. (1)

(1) Institute of Fundamental Sciences, Massey University, Palmerston North, New Zealand; (2) Scion, Rotorua, New Zealand; (3) Institute of Agriculture and Environment, Massey University, Palmerston North, New Zealand

Abstract: Effectors are proteins secreted by plant associated organsims, such as fungal pathogens, that facilitate infection of specific plant hosts. Effectors directly or indirectly suppress host defence responses, or help to mask the pathogen from recognition by the plant. Plants can recognise and respond to specific effector proteins, resulting in a resistance response. Thus the study of effectors is important for understanding plant-pathogen interactions. We are investigating molecular players in the interaction of Dothistroma septosporum and pine. Possible effector genes were identified from the New Zealand D. septosporum genome using bioinformatics tools. Their sequence variability and indicators of adaptation were determined from the newly acquired genome sequences of 18 D. septosporum isolates. Based on these results, a set of effector candidates was selected for functional analysis. They were screened for virulence functions, as well as avirulence (induction of resistance responses) in non-host plants. Effector screening methods are not available for pine, thus various approaches to achieve this were trialled. Methods shown to be most efficient and reliable will be used to screen for resistant pine genotypes. The findings will contribute to the understanding of forest pathogens and ultimately provide crucial information about immune receptors, and their likely durability, for pine breeding.

DNB, transcriptome, bioinformatics, effectors

All Division 7 (Forest Health) Meeting

199 - Effects of global change on Mediterranean forest insects and interactions with pathogens

K9 (Konzerthaus Freiburg)

IUFRO17-2206 **Climate extremes promote prolonged diapause in winter pine processionary moth: consequences of bet-hedging**

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(1) University of Padova, Padova, Italy; (2) INRA Orléans, ORLÉANS, Italy

Abstract: Prolonged diapause (PD) occurs in a number of forest insects and is considered as a way to evade extreme conditions. The pine processionary moth (PPM) Thaumetopoea pityocampa/wilkinsoni goes through facultative PD as a pupa in the soil, however little information is available on its mechanism and factors involved. We tested the role of temperature on both the occurrence of PD and pupal morality using a data set consisting of published and unpublished information. We collected a total of 115 PD records referred to the period 1964-2015 for a total of 49 sites in 7 countries, covering the whole thermal distribution range of the species in the Mediterranean and Southern Europe. We found high geographic diversity in PD rate, as all individuals of Corsica mountains always had an obligatory PD of at least one year, while the PD rate in the rest of the range varied between 0 and 100. Lower and higher temperatures were associated with higher PD rate as well as with pupal mortality. We conclude that such a U-shaped relationship identifies the optimal conditions for the insect development, whereas PD is associated with ecologically marginal conditions. We discuss how climate change can affect the pattern of PD and consequently its population dynamics in the whole species range. Besides, to better understand the ecophysiology of PD, we measured pupal metabolic rate in relation to temperature both in laboratory and field, on a number of populations collected along a climatic gradient in the Southern Alps. Preliminary data show that low temperature in the early pupa stage plays a major role in PD induction.

range edge, life history, risk-spreading,

K9 (Konzerthaus Freiburg)

IUFRO17-500 **How does global change shape the distribution of forest insects and pathogens?**

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Abstract: Global change represents all changes on Earth, encompassing large-scale anthropogenic changes and climate change. With the intensification of the world trade, the probability to carry unintentionally infested materials has considerably increased, enhancing dramatically the number of biological invasions. Once introduced, some exotic species may find better climate conditions with the ongoing climate warming. Forest health can be threatened by newly arrived exotic pests but also by native pests shifting or extending their distribution resulting from both climate change and human-assisted dispersal.

As an introduction to the following lectures about insects and pathogens distribution, we review how global change can shape the distribution of three model species. 1) The pine processionary moth, *Thaumetopoea pityocampa*, is an emblematic Mediterranean insect species responding to climate warming. The species range expansion is mostly explained by higher larval survival in winter and also by human-mediated dispersal. 2) The pine wood nematode, *Bursaphelenchus xylophilus*, is an invasive organism, now widespread in the western part of the Iberian Peninsula, causing the pine wilt disease under some environmental conditions. High summer temperatures enable the development of the disease and the tree death. Due to complex interactions with pine trees and a native vector insect, *Monochamus galloprovincialis*, this nematode can profoundly disturb Mediterranean forest ecosystems. 3) The invasive pathogen, *Phytophthora cinnamomi*, is the causal agent of a devastating decline that threatens Mediterranean oaks ecosystems. Occurring through the Mediterranean area, the pathogen is spread by tree trade and by drainage water. This pathogen is moreover favored by the ongoing climate warming. Understanding and predicting ecosystem disturbance and resilience of Mediterranean forests in this context constitutes one of the main challenges of the coming years.

Climate change; spread; insect; pathogen; forest

K9 (Konzerthaus Freiburg)

IUFRO17-1943 **Patterns of expansion of pine processionary moth and its specialist egg parasitoid at the northern edge of its distributional range.**

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(1) URZF-INRA, Orleans Cedex 2, France; (2) DAFNAE-Entomologia, Università degli Studi di Padova, Legnaro, Italy; (3) CBGP-INRA, Montferrier-sur-Lez Cedex, France

Abstract: For several insect species there is strong evidence that the on-going climate change affects both their distributional range and phenology. Range expansion can be accelerated by human-mediated dispersal, with the establishment of new insect populations in suitable areas far from the native range, possibly due to the increase of inter-and intra- continental ornamental plant trade. A rapid expansion or long distance dispersal can lead to a decoupling of trophic interactions between the expanding insect species and its natural enemies, with a resulting higher risk of outbreaks. The pine processionary moth (Thaumetopoea pityocampa) is one of the main forest pine tree pests in the Mediterranean basin. During the last decades this species has naturally expanded both to higher latitudes and altitudes due to the recent climate change. In France, the northward expansion occurred in a few decades and the distribution edge has now reached the Paris basin and northern Brittany. More, isolated populations were recently identified beyond the front edge. Both host tree distribution outside forests and accidental human transportation also seem to play a key role in the spread of the moth. In this study we considered populations of pine processionary moth in the front expansion edge and potential source populations from the native range. Samples were analyzed using 22 microsatellite loci in order to identify the main expansion patterns in relation to host plant distribution and other environmental factors. Finally, a preliminary comparison between the expansion patterns of the pine processionary moth and its specialist egg parasitoid Baryscapus servadeii was carried out using a first set of microsatellite loci to determine if this species can follow its host during the expansion.

range expansion,climate change,man-aided dispersal

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199 - Effects of global change on Mediterranean forest insects and interactions with pathogens

K9 (Konzerthaus Freiburg)

IUFRO17-68 **Climatic and anthropogenic influences on forest susceptibility to bark beetles in Mediterranean forests of California, U.S.**

Fettig, C. J.* (1)

(1) Pacific Southwest Research Station, USDA Forest Service, Davis, United States

Abstract: Bark beetles (Coleoptera: Curculionidae, Scolytinae), a large and diverse group of insects, are recognized as important disturbance agents in many forests. While some 200 species are native to California, only a handful is capable of causing tree mortality. Trees of all species, ages and size classes may be colonized and killed, but each bark beetle species exhibits unique host preferences, life history traits, and impacts. Some level of tree mortality results in a mosaic of age classes and tree species compositions that increase resistance and resilience to multiple disturbances. However, this differs from the impacts associated with large infestations or outbreaks, which may negatively affect many ecological goods and services. I discuss the impact of climatic and anthropogenic (e.g., management activities and land use patterns) influences on forest susceptibility to bark beetle infestations, focusing on efforts to restore ecological resilience to these systems.

climate change, drought, resistance, resilience

K9 (Konzerthaus Freiburg)

IUFRO17-668 **Various levels of interactions between an invasive ambrosia beetle Euwallacea nr. fornicatus, its symbiotic fungi and the host trees in the Mediterranean**

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(1) Agriculture Research Organization , Rishon LeTsiyon, Israel

Abstract: Since 2010 severe damage and mortality of several tree species has been observed in Israel caused by Euwallacea nr. fornicatus. Three single clonal fungi Fusarium euwallaceae, Graphium euwallaceae and Paracremonium pembeum were isolated from the beetle mycangia the brood galleries. F. euwallaceae is introduced during the early phase of tree colonization and is responsible for the injury to the host plant. G. euwallaceae is probably their main food source, whereas the role of P. pembeum is not yet clear. Artificial injections to healthy xylem of each of the three fungi alone into the xylem of healthy trees suggested that only F. euwallaceae survives for long periods while the other two rapidly disappear from the live issue. F. euwallaceae is dominant during the early stage of the xylem colonization. f F. euwallaceae was isolated only a few cm away from the beetle brood galleries. The gallery excavation increases the incidence of F. euwallaceae which in turn causes the wilt of the colonized branch and eventually the entire tree. Towards the end of the beetle offspring development, the other two fungi were mainly isolated from the dying or dead tree tissue. The most susceptible tree species recorded so far in Israel are two oak species, Quercus robur and Q. pedunculiflora, oriental plane Platanus orientalis, two box elders, Acer negundo and A. buergerianum, and castor bean Ricinus communis. In these hosts the beetle successfully breeds in thick stems and limbs, and to a lesser extent in avocado Persea americana where brood galleries occur in rather thin branches. Flight activity occurs during the warm season and becomes more intensive toward the end of summer. Within six years, since the beetle was discovered, it has covered most of the potential habitats in Israel. Currently, management of the problem is mainly based on prevention measures, and application of systemic insecticides may help to cure the tree if applied at an early phase of the infestation.

Scolytinae; Xyleborini, Symbiotic fungi, ambrosia

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83 - Are we doing the right things to deal with invasive forest pest and pathogens? Lessons from history

KG I - 1199 (Uni Freiburg)

IUFRO17-156 **Tree Resistance as a Primary Tool for Managing Forest Pathogen and Insect Invasions in Defense-Free Space**

Showalter, D. (1); Smith, J. (2); Raffa, K. (3); Sniezko, R. (4); Herms, D. (1); Liebhold, A. (5); Bonello, P.* (1)

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Abstract: Massive global trade of goods is facilitating movement of alien phytophagous insects and phytopathogens (PIPs) of trees. A fraction of these organisms defeat measures intended to exclude them from naïve forest ecosystems, e.g. those designed to prevent transport or to eradicate early infestations. Eventually, some cause severe economic and environmental impacts by killing vast numbers of trees, occasionally on continental scales.
It is becoming increasingly clear that many of the most devastating alien PIPs become invasive largely due to a lack of bottom-up control that is otherwise exerted by host defenses in their native region. These PIPs, acting in the "defense-free space" of naïve environments, are often intimately and cryptically associated with their hosts, which makes early detection very difficult, and damage tissues with high fitness value and low compensatory mechanisms, thereby quickly killing their hosts and limiting the effectiveness of density-dependent biological control.
We posit that once such PIPs become established, responses should immediately and sustainably integrate strategies that transition valuable tree populations toward an environment in which these particular PIPs exist in "defense-constrained space", i.e. through the development of host resistance. A combination of traditional selection and breeding, rapidly advancing genomic and phenotypic marker techniques, and targeted genetic engineering, offers great potential to accelerate development and deployment of diverse populations of locally-adapted, PIP-resistant trees. Integrated host resistance development programs have considerable potential to conserve and/or restore threatened tree species and their ecosystem services, as productive components of urban, plantation and naturally regenerating forests.

invasions, pests, pathogens, tree resistance

KG I - 1199 (Uni Freiburg)

IUFRO17-4044 **Role of sea containers in unintentional movement of invasive "hitchhiker" pests - a closer look at a barely managed pathway**

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(1) Scion (New Zealand Forest Research Institute), Christchurch, New Zealand; (2) USDA Forest Service, Morgantown, WV, United States; (3) Scion (New Zealand Forest Research Institute), Rotorua, New Zealand

Abstract: The volume of international trade is at unprecedented levels, and much of this is moved with so-called "sea containers". An unwanted by-product is the transport of "hitchhiker pests" on the external or internal surfaces of sea containers, which may become invasive species. Hitchhiker pests found on sea containers, such as gypsy moth, giant African snail, Argentine ant and brown marmorated stink bug, threaten forests and other environments worldwide. Soil contamination of sea containers may contain seeds of invasive plants, nematodes and plant pathogens. A summary will be presented of records from sea container inspections by quarantine officers along with a review of previous work on risks associated with this pathway and an evaluation of the likely benefits of mitigation measures. Inspection records from the United States, Australia, China and New Zealand indicate that thousands of organisms from a wide range of taxa are being moved unintentionally with sea containers. Records of more than 100,000 consignments of empty sea containers recently arriving in New Zealand indicated a contamination rate of nearly 15%. A sea container hygiene system implemented in New Zealand showed that a range of measures can be highly effective in reducing infestation rates. There is a strong case to implement such measures internationally, to address pathway risks that are currently largely unmanaged.

invasive species, pathway risk management

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IUFRO17-1331 **Different invasive forest pathogens need different management strategies, a view from a Mediterranean perspective**

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Abstract: Historically, Mediterranean countries were invaded by many alien forest pests. Among causal factors, large human population and population density, and high imports were identified. A great number of invasive pathogens is thus the result of a long history of continuate commercial exchange and human activity.
Moreover, Mediterranean countries host high environmental variety and biodiversity that, with a generally mild climate, favor the establishment of various organisms. Such a high environmental diversity likely increased the arrival and spread rates of microbes helping the establishment of many forest pathogens with diverse niches.
Army supply during WWII was the most likely introduction pathway for three serious pathogens spreading today in the Mediterranean area: Seiridium cardinale, the agent of cypress canker, Ceratocystis platani, the agent of plane canker stain, and Heterobasidion irregulare, the cause of root and butt rot in pines.
S. cardinale reproduces asexually and parasexually, while C. platani reproduces asexually and sexually, being hermaphroditic and self-fertile. H. irregulare reproduces mainly gamically, but also by asexual spores. S. cardinale is mainly spread by occasional insect vectors, the dispersal of C. platani is mostly human-mediated, while H. irregulare is air-dispersed.
Distinctive traits and differentiated management strategies for each pathogen led to different outcomes. S. cardinale spread in the Mediterranean basin until an equilibrium between pathogen and host was reached. Despite huge control efforts, C. platani spread in Italy, southern France and Switzerland; jumped to Greece and Albania, and spreads now eastward to the center of Platanus orientalis native range. H. irregulare, despite no control actions, is present in Pinus pinea stands on 103 km of seacoast near Rome and spreading at 1.3 km/year.
Specific lifestyle and bio-ecological traits of these fungi that possibly influenced their invasiveness , were compared in this work.

alien pathogens, canker, rot, reproduction, spread

All Division 7 (Forest Health) Meeting

83 - Are we doing the right things to deal with invasive forest pest and pathogens? Lessons from history

KG I - 1199 (Uni Freiburg)

IUFRO17-1207 **Biological control of insects in plantation forests: Optimising an old approach for diverse and changing environments**

Hurley, B.* (1); Slippers, B. (1); Wingfield, M. (1)

(1) Forestry and Agricultural Biotechnology Institute (FABI) , University of Pretoria, Pretoria, South Africa

Abstract: Biological control remains one of the most effective strategies to manage populations of pest insects in plantation forestry, especially where non-native trees are established. An increase in the global plantation area, rate of insect pest introductions and restrictions on the use of insecticides, will further escalate the importance of biological control in the future. In addition, optimisation of current biological control approaches will be required in order for this approach to be effective over diverse and changing environments. We use three case studies, namely the biological control of the Sirex woodwasp, *Sirex noctilio*, the Eucalypt snout beetle, *Gonipterus* spp., and the bluegum chalcid, *Leptocybe invasa*, to illustrate current efforts to optimize biological control in plantation forest systems. In all these cases, DNA-based tools have been used to characterize the genetic diversity of the pest and / or biocontrol agent populations. Data from these studies are providing opportunities to test for the effect of diversity on biocontrol success. DNA-based tools are also being used to unravel the interactions between gall-formers, parasitoids and inquilines that co-inhabit the galls of *Leptocybe invasa*. While classical biological control has been the major focus for the above and many other plantation pests, augmentative and conservation biological control approaches deserve greater attention.

genetic diversity, interactions, invasive species

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IUFRO17-3061 **The role of molecular ecology in the management of invasive pests and pathogens in plantation forestry**

Slippers, B.* (1)

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Abstract: The number of invasive pests and pathogens in plantation forests globally has increased dramatically over the past 30 years. Over the past two decades, and in particularly the last 10 years, phylogeographic and population genetic analyses have helped to unravel the pathways and extent of these introductions. The emerging picture is one of complex introduction histories, often with large and multiple spread events out of the native range, and between invaded regions. Clearly there have been large gaps in the application of quarantine and management to stem these invasions, and this requires careful thought to amend in future. The understanding of these invasions have been driven by technical advances in molecular characterization of species and their populations, and this continues to deepen as genomics is increasingly applied to forest pests and pathogens. This overview will consider how these tools and the existing information, often scattered between databases, can be better used to monitor and manage the movement of quarantine pests and pathogens. I will also consider the relevance of this information for emerging genome editing and gene drive systems as potential management tools for population control of invasive pests.

Invasive pests, molecular ecology, genome editing

KG I - 1199 (Uni Freiburg)

IUFRO17-1538 **New methods for the biological control of chestnut blight assessed with a mark-release-recapture experiment**

Meyer, J. B.* (1); Fässler, F. (1); Rigling, D. (1); Prospero, S. (1)

(1) Swiss Federal Research Institute WSL, Birmensdorf, Switzerland

Abstract: Cryphonectria parasitica (Cp), the causal agent of chestnut blight, is locally controlled in Europe by the naturally occurring Cryphonectria hypovirus 1 (CHV1). At the front of the disease, however, CHV1 is often not present and its artificial introduction via canker treatment is laborious and time consuming. In this study, two new methods of treatment were tested for their CHV1 transmission efficiency. In the first treatment, freshly cut wood stems colonized by a CHV1-infected Cp strain were placed above virulent cankers. In the second treatment, a solution of CHV1-infected conidia was sprayed onto cankers. In four different stands, virulent artificial cankers were produced on chestnut sprouts and then treated. To analyze CHV1 transmission, Cp was isolated at four time points during two years and canker size, sporulation and morphology were assessed. A mark-release-recapture method was used to trace back the released biocontrol strains and study the disease epidemiology in the chestnut stands. Fitness of each biocontrol strain was assessed in vitro and compared to the performance in vivo. Both treatments were similarly effective in transmitting CHV1 to the artificial cankers. Considering all sites, 66 % of the treated cankers were infected with the applied viral strain. Canker size was significantly smaller and the number of overgrown cankers higher in the treatment with conidial spray than with colonized wood stems. Differences in fitness and spread were observed between Cp genotypes. The ease of application, in combination with the high CHV1 transmission rate, show the efficiency of the two new treatments to complement or even replace the classical canker treatment. With the mark-release-recapture method valuable information about the epidemiology of this fungus-virus interaction could be gained. Besides that, this study opens interesting questions about the management of dead wood in blighted chestnut forests.

Cryphonectria, canker, CHV1, biocontrol, deadwood

All Division 7 (Forest Health) Meeting

86 - The science of tree health and how we can: Multidisciplinary research from the Tree Health and Plant

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2261 **Community-based biotic effects as determinants of tree resistance to pests and pathogens**

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Abstract: In the light of the global increase in forest pests and diseases, we review recent advances in community biotic interactions of trees with other organisms, and consider their theoretical underpinning, likely response time to implementation, and potential future application to confer stability and resilience to forests against pests or pathogens. These include associational resistance (AR) by manipulation of tree species composition or richness, genotypic diversity, or by tree density/frequency of resistant species or genotypes, use of hybrids, and strategic use of bacterial and fungal symbionts to engender systemic induced resistance, or defense priming. They can be used as part of a general long-term prophylactic strategy by structuring future forests to increase their general resistance, and reduce the probability of impacts of pests and diseases, eg via diversification of tree species and genotypes. But long rotation times in forest production systems, mean that community-based actions to disrupt a tree-pest or tree-pathogen interaction, cannot be used in a rapidly targeted response to currently known pests or pathogens, or to unknown ones that are yet to emerge. The only exception is the possible use of mutualistic organisms to induce systemic resistance or prime tree generic or specific defence systems against attack.

resilience resistance pests pathogens communtiy

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1977 **Discrimination Between Species of Phytophthora Using Volatile Organic Compound Signatures**

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(1) University of Aberdeen, Institute of Biological and Environmental Sciences, Aberdeen, United Kingdom; (2) University of Aberdeen, Department of Chemistry, Aberdeen, United Kingdom

Abstract: Many plant pathogenic organisms are known to release volatile organic compounds (VOCs) into their environment, raising the intriguing possibility that the detection of these chemical signatures could be used in determining the presence of pathogens in plants, plant products and growth substrates. A combination of solvent extraction of entire cultures, and alternatively, trapping of volatiles using headspace techniques and adsorption onto SPME fibres was monitored by gas chromatography-mass spectrometry (GC-MS) and subsequent statistical analysis. With this approach, we were able to differentiate between representative species in 9 clades of the genus Phytophthora. After including adequate controls for individual growth media, principal component analysis (PCA) distinguished 13 species of Phytophthora. This study particularly highlighted VOC profiles of P. citrophthora, P. cryptogea, P. cambivora and P. psychrophila, which were clearly separated from other species. The ultimate goal of our study is to further modify this method to be applicable to ion mobility mass spectrometry for the rapid detection of pathogens in commercially traded plants.

VOCs; Phytophthora; detection

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-117 **Applying agent based modelling to inform on the impact of technological and behavioural changes in tree health management**

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Abstract: In the fight against tree pests and diseases we are constantly looking to detect the next outbreak before it becomes unmanageable. To do this we often explore the use of new technologies that could lead to earlier detection by increasing test sensitivity or specificity. However, developing a new technology is only part the story, because how the new technology is deployed and integrated with the disease or pest management can have as much, if not more, impact on the success of the control programme. As part of the LWEC Early Detection of Tree Pests and Pathogens project we have used agent-based modelling to simulate both the spread of pests and disease, and the integration of improving detection technologies in surveillance and control activities for that pest or disease. We couple the outputs from the agent based model to an economic model to estimate the value lost due to the impacts of the pest or disease, along with calculating the expected costs of the testing and control strategy. We compare the agent-based modelling with mathematical models for predicting detection and will talk about the benefits of using such models for assessing the expected impact of introducing new technologies as well as discussing some of the limitations inherent in using these models.

Agent Based Modelling, Tree Health, Detection

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86 - The science of tree health and how we can: Multidisciplinary research from the Tree Health and Plant

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1662 **Pine processionary moth eggs, early instar larvae and pupae are susceptible to the entomopathogenic fungus Metarhizium brunneum**

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(1) Süleyman Demirel Üniversity, Faculty of Agriculture, Isparta, Turkey; (2) Süleyman Demirel Üniversity, Faculty of Forestry, Isparta, Turkey; (3) Swansea Universtiy, Department of Biosciences, Swansea, United Kingdom

Abstract: Pine processionary moths (PPM, Thaumetopoea wilkinsoni and T. pityocampa) feed on the needles of pine and occasionally larch and cedars. Besides being a major pest of pines, the larvae pose a threat to human and animal health since their setae contain a highly allergenic toxin. Adult females lay 70-300 eggs in cylindrical masses (4-5 cm in length) around pairs of needles usually at the periphery of the tree. The eggs are covered with the scales of the female anal tuft. The first two instars are extremely tiny and will produce silken threads but not until the 3rd instar will they produce robust silken nests. Larvae feed at night and rest in the nest during the day. The 5th instar larvae form processions when they leave the nest to pupate in the soil. Pupation takes place in an oval, ocheous-white silken cocoon. Soil particles usually stick to the cocoon surface and appear to seal the pupa within this cell. The current study shows that the entomopathogenic fungus (EPF), Metarhizium brunneum, can be used to control both 1st instar larvae, nest of 3rd instar larvae and late instar larvae during pupation. Exposing the egg masses to conidia of M. brunneum suppresses egg hatching or kills all the emergent larvae. EPF treated pine leaves also caused 83% mortality, 5 days post inoculation. The 3rd instar larvae inside the nests were very susceptible to M. brunneum isolates and 100% fungal infection was observed. Exposure of 5th instar larvae to soil treated with M. brunneum results in infection immediately prior to and during pupation. Most of the larvae (64-92%) were killed inside the "pupal cell" but some were killed before they could spin a cocoon. Control mortality was less than 10%. The formulation and application of EPF for control of PPM larvae and pupae is discussed.

Pine processionary moths, Metarhizium brunneum

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2256 **Identifying resistance traits in Scots pine (Pinus sylvestris) to the pine tree lappet moth (Dendrolimus pini)**

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Abstract: Scots pine (Pinus sylvestris) is widely distributed from Western Europe to China and from the Mediterranean to the Arctic, and is of great economic, ecological, and cultural significance. Native Scots pine woodland in Scotland is threatened by invasive and exotic phytophagous insects and pathogens for which it may have few co-evolved defenses. One such pest is the pine tree lappet moth (PLM; Dendrolimus pini), a defoliating caterpillar believed to be recently introduced into Scotland from continental Europe, the threat from which is dependent upon its rates of maturation and completion of stages of its life-cycle. In order to identify defensive traits in Scots pine active against PLM, wild caught and captive-bred PLM larvae were fed cut branches from individual trees selected from four native Caledonian forest populations. Their larval growth rates and other growth parameters were measured in order to assess tree and population differences in host quality. Corresponding needle tissue is being comprehensively analyzed for several biochemical traits that may be associated with Scots pine resistance or susceptibility to PLM including: terpenes, tannins, phenolics, defensive proteins, N content, soluble sugars, fiber. Additionally, this study will generate a detailed phenological and ontogenetic analysis of patterns in needle biochemistry at the various forests. Large differences in insect performance and variations of chemical profiles give hope that native Scots pine has enough adaptive potential to survive widespread colonisation by PLM. This study will prove invaluable for predicting the resilience of Scots pine to this and other invading pests and defining chemical markers for resistance breeding efforts.

Scots pine, plant defense, metabolomics, insect

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2346 **Using integrated epidemiological and economic modelling to assess silvicultural options for forest resilience under uncertain future risk of tree diseases**

Healey, J.* (1); Dangerfield, C. (2); Macpherson, M. (3); Hanley, N. (4); Quine, C. (5); Gilligan, C. (2); Whalley, E. (6); Sheremet, O. (4); Kleczkowski, A. (3)

(1) School of Environment, Natural Resources and Geography, Bangor University, Gwynedd, United Kingdom; (2) University of Cambridge, Cambridge, United Kingdom; (3) University of Stirling, Stirling, United Kingdom; (4) University of St Andrews, St Andrews, United Kingdom; (5) Forest Research, Roslin, United Kingdom; (6) University of Warwick, Coventry, United Kingdom

Abstract: We propose a bioeconomic modelling framework to link silvicultural options with emergence and spread of tree pests and diseases, and their subsequent impact on provisioning (e.g. timber) and regulating and cultural (e.g. carbon sequestration, biodiversity) ecosystem services. Mapping silvicultural options onto economic, ecological and epidemiological parameters and variables within the framework provides new ways to quantify resilience, defined as the forests' capacity to sustain delivery of a value flow of ecosystem services over time under external "shocks" from invasive pests and diseases. To test their incorporation into the modelling framework, we searched for existing empirical results of the effect of silvicultural practices on four epidemiological components: risk of exposure, resistance, capacity for recovery, and risk of infecting other trees and forests. We classified the components of silvicultural options as: tree species identity, tree species diversity, within-stand structural diversity, and between-patch landscape-scale structural diversity. We show how these management options can be modelled within the bioeconomic framework to estimate impacts on the level and variance of the flow of ecosystem services in the presence of disease. Findings focus on identifying priorities for future empirical research, and for policy interventions through subsidy payments and market incentives.

bioeconomic, ecosystem services, biodiv, landscape

All Division 7 (Forest Health) Meeting

5 - Open Session

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-616 **Working with trees, ecosystems, diseases and people: developing new ways of researching tree health in the borderlands**

Geoghegan, H.* (1); Dyke, A. (2); de Bruin, A. (2)

(1) University of Reading, Reading, United Kingdom; (2) Stockholm Environment Institute, York, United Kingdom

Abstract: There is an urgent need to understand the causes and consequences of tree health issues. Rising numbers of pests and diseases affecting trees in the UK have led to increased funding for researchers to investigate tree health, its social implications, and associated policy developments. In the PuRpOsE project, we combine disciplinary expertise from microbiology, ecology, soil biogeochemistry, climate science, environmental social science and cultural geography to investigate oak tree health and acute oak decline in particular. Our project seeks to challenge 'business as usual' in the field of tree health in order to develop new ways of understanding, working and living with disease.

In this presentation, we argue that the notion of 'borderlands', which has been developed by scholars in the area of animal health and biosecurity, is useful in understanding tree health. For Hinchliffe et al. (2013:532), disease is "both integral to, and always part of, an entangled [and always changing] interplay of environments, hosts, pathogens and humans". In this presentation, we draw on the example of a two-day PuRpOsE project workshop in Epping Forest in North London, where oak trees, ecosystems, diseases and researchers were thrown together to share each others languages, expand our understanding of oak declines, and accommodate trees and the diseases affecting them as key agents in our research.

Effective tree health research demands an approach that addresses the links between environments, hosts, pests/pathogens and humans . We conclude with a challenge for tree health and forest researchers to examine more fully the active role of 'humans' and 'non-humans' in their work.

Tree health, oak, decline, humans, nonhumans,

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165 - Dothistroma and other needle diseases of pine

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3147 **Shoot And Needle Diseases Of Pines In Turkey**

Lehtijarvi, A. T.* (1); Oskay, F. (2); Dogmus-Lehtijarvi, H. . T. (3); Mullett, M. S. (4); Woodward, S. (5); Aday Kaya, A. G. (6)

(1) Bursa Technicial University, Faculty of Forestry, Bursa, Turkey; (2) Çankiri Karatekin University, Faculty of Forestry, Çankiri, Turkey; (3) Suleyman Demirel University, Faculty of Forestry, Isparta, Turkey; (4) Forest Research, Alice Holt Lodge, Farnham, United Kingdom; (5) Aberdeen University, Institute of Biological and Environmental Sciences, Aberdeen, United Kingdom; (6) Suleyman Demirel University, Yenisarbademli Vocational School, Isparta, Turkey

Abstract: Pine forests comprise over half the total forest area of Turkey. Most existing pine forests of the indigenous pine species Pinus brutia, P. nigra subsp. pallasiana and P. sylvestris are naturally regenerated semi-natural forests with high genetic diversity. Until recently, disease problems in the pine forests received little attention in Turkey, from both the scientific and management points of view. Even though a lack of nation-wide surveys limits full analysis, Dothistroma septosporum affecting P. brutia, particularly in the western Mediterranean part, seems to be the most threatening needle disease of pines in Turkey. In contrast, the stress-related shoot disease caused by Diplodia sapinea is possibly the most widespread disease of pines and causes considerable chronic damage on both native and exotic pines. The current status of needle and shoot diseases of pine in Turkey, together with future threats will be discussed.

Dothistroma, Lophodermium, Diplodia, Turkish pine

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3862 **Insights into the pathways of spread and potential origins of Dothistroma septosporum in Britain**

Mullett, M.* (1); Brown, A. (2); Tubby, K. (1)

(1) Forest Research, Farnham, United Kingdom; (2) Forestry Commission, Edinburgh, United Kingdom

Abstract: Dothistroma needle blight (DNB) is a foliar disease of pine caused by two fungi, Dothistroma septosporum and D. pini, that has resulted in significant damage to pine forests worldwide. Analysis of 1,194 British Dothistroma isolates revealed that only D. septosporum occurred in Britain, where DNB has caused severe damage since the 1990s. Dothistroma pini, the other causal agent of DNB, was not detected. The genetic diversity, population structure, and reproductive mode of D. septosporum in Britain were investigated using species-specific mating type markers and eleven microsatellite markers. Comparison of clustering methods (STRUCTURE, BAPS, DAPC) as well as spatial principal component analysis (sPCA) revealed differences between the methods but similar groupings of the 382 multilocus British haplotypes. A clear north-south cline was found with high genotypic diversity, low clonal fraction and strong support for sexual recombination in the group indicating the native range of the fungus may include Britain. However, distinct groups also occurred in certain areas of Britain, some of which are most likely introductions. A distinct, highly clonal group occurred in central Scotland and affinity to Canadian isolates suggests this group may have been introduced from the native range of its predominant host, lodgepole pine. Other clusters, as well as a number of identical multilocus haplotypes, were found in both Britain and France supporting a degree of pathogen exchange between these countries and drawing attention to the risk of introducing D. pini into Britain. A number of multilocus haplotypes likely to correspond to those of the first outbreak of the pathogen in the 1950s were found in areas known to have received stock from the outbreak area and highlight the importance of human-mediated dispersal pathways. Limiting the spread of new Dothistroma species and populations remains crucial to safeguarding Britain's pine forests from further DNB damage.

Dothistroma, microsatellites, SSR, population

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3702 **High throughput monitoring of Dothistroma and Lecanosticta needle blight in Switzerland**

Schneider, S.* (1); Jung, E. (1); Schwarz, J. (1); Dubach, V. (2); Rigling, D. (1); Queloz, V. (2)

(1) Swiss Federal Institute for Forest, Snow and Landscape WSL, Biodiversity and Conservation Biology, Birmensdorf, Switzerland; (2) Swiss Federal Institute for Forest, Snow and Landscape WSL, Forest Dynamics, Birmensdorf, Switzerland

Abstract: Both Dothistroma and Lecanosticta needle blight belong to the most damaging foliage diseases in natural pine stands and plantations worldwide. The needle blights are caused by three fungal species, which are registered as quarantine organisms in Europe: Dothistroma septosporum, D. pini are responsible for the Dothistroma and Lecanosticta acicola for the Lecanosticta needle blight. The infection of the needles results in reduced tree growth and consequently low biomass productivity or even death of the trees. For both needle blight diseases the trees show similar symptoms and the pathogens causing Dothistroma needle blight can be clearly segregated using DNA-based techniques only. First reports of the diseases in Switzerland date from 1989 for Dothistroma and 1995 for Lecanosticta. The aim of this study was to obtain an overview on the abundance and spatial distribution of the three pathogens in forests as well as urban areas in Switzerland. With quantitative PCR, the abundance of all three quarantine pathogens was monitored on needles collected at almost 400 locations with five trees each in 2016. In addition, collected needles were screened morphologically for the presence of fruit bodies or spores. Automated DNA extraction and multiplex quantitative PCR allowed for fast and reliable screening of around 8000 needles, of which less than 10% were positive for one or more of the needle blight pathogens. Among the three diagnosed species, D. septosporum was the most common (62.4%), followed by L. acicola (34.6%). In contrast, D. pini was rarely found (3%). In conclusion, the three quarantine pathogens are present in Switzerland and phytosanitary measures need to be defined to avoid further increase of the diseases and their impacts on pine trees.

Dothistroma, Lecanosticta, molecular diagnostic

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165 - Dothistroma and other needle diseases of pine

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2424 **New cryptic species and a putative center of diversity for the pine pathogens Dothistroma and Lecanosticta **

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(1) Forestry and Agricultural Biotechnology Institute, University of Pretoria, Pretoria, South Africa; (2) Instituto Nacional de Bosques (INAB) , Guatemala City, Guatemala

Abstract: Brown spot needle blight (BSNB) caused by *Lecanosticta acicola* and Dothistroma needle blight (DNB) caused by *D. pini* and *D. septosporum*, are two of the most important needle diseases of *Pinus* spp. Based on substantial morphological variation observed within isolates from native *Pinus* forests, Central America has been hypothesized as the area origin of these causal pathogens. The aim of this study was to use molecular methods to characterise a large collection of isolates from Guatemala. A total of 182 isolates were obtained from needles of four native pine species collected in three areas of the country. The ITS, TEF, BT1, MS204 and RPB2 gene regions of representative isolates were sequenced and subjected to phylogenetic analyses. *Dothistroma septosporum*, *L. brevispora* and *L. guatemalensis* were identified from the samples but neither *L. acicola* nor *D. pini* were isolated. In addition, multigene phylogenies revealed several new cryptic species of *Lecanosticta* and *Dothistroma* that are currently being described. Preliminary screening of the *D. septosporum* isolates using microsatellite markers revealed a unique allele not found in isolates that are causing DNB elsewhere in the world. The large number of undescribed species found in this study suggests that Central America is a center of diversity of both *Lecanosticta* and *Dothistroma*. Importantly, many species emerging from this study are known only in Central America suggesting a quarantine risk if infected plant material were to be moved out of this area.

DIAROD, Dothideomycetes, red band needle blight

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2556 **How Common is Dothistroma Needle Blight in Botanic Gardens and Arboreta?**

oskay, F.* (1); Aday Kaya, A. G. (2); Cleary, M. (3); Woodward, S. (4); Dogmus Lehtijarvi, H. . T. (5); Lehtijarvi, A. (6)

(1) Çankiri Karatekin University, Çankiri, Turkey; (2) Süleyman Demirel University, Yenisarbademli Vocational School, Isparta, Turkey; (3) Swedish Universty of Agricultural Sciences, Southern Swedish Forest Research Centre, Alnarp, Sweden; (4) University of Aberdeen, Institute of Biological and Environmental Sciences, Aberdeen, Scotland, United Kingdom; (5) Süleyman Demirel University, Faculty of forestry, Isparta, Turkey; (6) Bursa Technical University, Faculty of forestry, Bursa, Turkey

Abstract:
Dothistroma needle blight (DNB), caused by the fungal pathogen Dothistroma septosporum, is an important disease affecting of Pinus species worldwide. Although Pinus is the main host genus affected by the disease, a recent review on the distribution and host range of DNB named 109 Pinaceae host taxa, including species of Abies, Cedrus, Larix, Picea and Pseudotsuga.

While D. septosporum has the characteristics of a successful invasive species, its presence on a wide range of native and exotic hosts planted in botanic gardens or arboreta presents a potential threat to native biodiversity. Rapid and reliable detection of foliar needle pathogens can be achieved by PCR using species-specific primers. This is a common diagnostic tool that has been successfully employed to identify potentially damaging agents including D. septosporum and D. pini.
In this work, surveys were conducted in parks and arboreta in Turkey, Sweden and Scotland on several Pinaceae comprsing species of Pinus, Abies, Cedrus, Larix, Picea and Pseudotsuga. Needles were collected and screened for the presence of Dothistroma pini and D. septosporum with PCR using species-specific primers.

Dothistroma, early warning, sentinel arboreta

All Division 7 (Forest Health) Meeting

199 - Effects of global change on Mediterranean forest insects and interactions with pathogens

K9 (Konzerthaus Freiburg)

IUFRO17-963 **Geographic Area of the Pin Processionary Moth (Thaumetopea pityocampa Schiff, Lepidoptera) in the Southern Aleppo Pine Forests and Effect of the Climatic Change**

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(1) National Institute of Research in Forests, Ariana, Tunisia

Abstract: Among the disturbances of forest ecosystems in the context of climate change, changes in areas of distribution of insects in particular due to rising temperatures. More specifically, it is shown that the Pine Processionary Moth (PPM) has spread its range in the northern part of its distribution. The general objective of this study was therefore to determine the range of Thaumetopoea pityocampae in southern Alepo pine forests of Tunisia.
This study was carried out in the south of Tunisia, where 26 localities (planted with Aleppo pine) were investigated between Mai and October 2014. The situation of the PPM was determined through surveys of forest technicians, forest rangers and field visits. The gathered information's is used for carrying out the mapping of infestation.
Land investigations showed that the PPM no longer exists in the southern forest of Tunisia. The disappearance of T. pityocampae can be attributed to the extreme temperatures of the months from July to September that can exceed 45 °C. Indeed, a clear upward trend in temperature and extreme temperatures of over 45 °C were recorded especially in the 2000s during July and August in the southern regions of Tunisia. This period coincides with the flight of the adults, which are to be very affected by these lethal temperatures.
Analysis of the egg-batches under microscope show that the fertility of females varies from 12 to 264, the percentages of hatched eggs 48.61%, parasitized eggs are 12.64%, and non-hatched caterpillars are 8.41%. 5.82% of infertile eggs and 24.51% of the remaining unhatched eggs. However, two species of parasitoids: Baryscapus servadeii and Ooencyrtus pityocampae emerged from eggs.

Aleppo pine, PPM, climate change, southern Tunisia

K9 (Konzerthaus Freiburg)

IUFRO17-1482 **Review on the impact of Leptoglossus occidentalis on stone pine in the Mediterranean countries**

Branco, M.* (1); Farinha, A. (1); Mutke, S. (2); Roques, A. (3); Sousa, E. (4)

(1) Instituto Superior de Agronomia, Universidade de Lisboa, Lisboa, Portugal; (2) INIA-CIFOR. Forest Research Centre, iuFOR. Institute UVa INIA , Madrid, Spain; (3) INRA Val De Loire, , UR0633 Zoologie Forestière, Orleans, France; (4) UEISSAFSV, INIAV, IP , Oeiras, Portugal

Abstract: Stone pine Pinus pinea is an important forest tree in many Mediterranean countries. Apart from its environmental, ecological and landscape value, the stone pine has a high economic value due to its edible seed kernels, the Mediterranean pine nuts, a gourmet nut with high market price. Nevertheless, strong decrease in the amount of cones harvested, as well as in kernel yield per cone, was recently observed in many Mediterranean countries causing concern to stakeholders and producers. The recently introduced, invasive species Leptoglossus occidentalis (Hemiptera, Coreidae), a bug feeding on conifer seeds and causing abortion of whole cones or of seeds within, has been pinpointed as the main cause of decline of the cone production and the drop in kernel yield. Here, we review data on the decrease of pine seeds production in several Mediterranean countries. Additionally, using feeding trials in laboratory and in field experiments we record damage caused by L. occidentalis in several stages of cone and seed development and in matured pine nut seeds and register feeding behaviour strategies and preferences.

Leptoglossus occidentalis, pine nut, Pinus pinea

K9 (Konzerthaus Freiburg)

IUFRO17-2191 **Do fungal mutualists determine invasion success in competitive interactions between ambrosia beetles?**

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(1) DAFNAE, University of Padova, Legnaro, Italy; (2) Max-Planck Institute for Chemical Ecology, Jena, Germany

Abstract: Global trade of timber has resulted in ambrosia beetles being amongst the most successful and detrimental invasive insects around the world. Being mostly host generalists, they typically colonize suitable trees in masses, which should lead to high competition not only between the beetles, but also between the food fungi they farm within tunnel systems and which grow far into the wood. Although these interactions could significantly hamper their invasion process, research on this topic is currently absent.
Here we performed the first intra- and interspecific competition study between the palearctic fruit-tree pinhole borer Xyleborinus saxesenii and the indo-malayan granulate ambrosia beetle Xylosandrus crassiusculus , both ubiquitous invasives worldwide, and their primary food fungi Raffaelea sulphurea and Ambrosiella roeperi. Interestingly, pairings of mated females from the same and different species had opposite effects on the offspring numbers of both species, if pairings were forced to breed together in artificial breeding substrate. X. saxesenii suffered more from inter- vs. intraspecific competition and viceversa for X. crassiusculus. This effect was not apparent in competitive interactions of the fungi on plates - there R. sulphurea outcompeted A. roeperi on five of six different growth media, which only explains the higher offspring numbers of X. saxesenii in interspecific pairings. Instead we speculate that the higher intraspecific competition in X. crassiusculus results from more cannibalism and/or competition for space as this species breeds close to the surface, while X. saxesenii can flexibly breed at different depths inside the breeding substrate. Overall our data suggests that the competitive abilities of both the beetles and their fungal mutualists determine the reproductive output of the beetles and that the fungi may play a more important role in the establishment and invasion success of alien ambrosia beetles than envisioned so far.

invasive species; competition; Scolytinae; fungi

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199 - Effects of global change on Mediterranean forest insects and interactions with pathogens

K9 (Konzerthaus Freiburg)

IUFRO17-2811 **Alien pathogens and native vectors: how to take advantages from new associations**

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Abstract: Two of the main plant disease epidemics in the Mediterranean area are Dutch elm disease (DED) and cypress canker. Dutch elm disease is caused by the Ascomycete Ophiostoma ulmi s.l., an alien invasive pathogen that is well known for having nearly wiped out native elms worldwide. Cypress canker is a pandemic disease due to the spread of the fungal pathogen Seiridium cardinal, which had a strong impact in the Mediterranean. Both these pathogens rely very much on insect vectors for their dispersal. In Ulmus spp., elm bark beetles originally had a mutualistic ectosymbiosis with the indigenous saprotrophic fungus O. quercus. Later, the arrival in Europe of the congeneric O. ulmi s.l., a fungus having niche requirements similar to O. quercus but far more aggressive, caused the complete replacement of the endemic fungus. The new association became an effective DED transmission pathway, with devastating consequences for elm survival. At the same time elm bark beetles transport several species of Geosmithia, which could have a mycoparasitic activity towards O. novo-ulmi, the very aggressive agent of the second DED epidemic. In Cupressus sempervirens, the association between seed insects and tree pathogens has resulted in optimal exploitation of the cones. A fungus-infected cone can be inhabited by the nymphs of a true seed bug (Orsillus maculatus), the adults of which may carry a heavy spore load at emergence. Cones are infected when eggs are laid within the cone, most frequently via the emergence holes of a seed wasp (Megastigmus wachtli). This symbiotic association evolved with the non-aggressive fungus Pestalotiopsis funerea within the natural range of the cypress. When the aggressive cypress canker disease (Seiridium cardinale) was introduced into Europe, it was transmitted by O. maculatus to cones usually colonized by Pestalotiopsis funerea, with disastrous consequences for the regeneration and survival of C. sempervirens in the entire Mediterranean area.

disease, pest, elm, cypress

K9 (Konzerthaus Freiburg)

IUFRO17-191 **Emergence of pests as results of global change**

Paine, T.* (1)

(1) Department of Entomology, University of California, Riverside, CA, United States

Abstract: Mediterranean forest systems are restricted in distribution because the unique environmental requirements upon which they depend are limited to only five places in the world. Characterized by cool wet winters and hot dry summers, these Mediterranean habitats are also biological hot spots for endemic species. Consequently , there is growing concern that global climate change could have disproportionate negative impacts on species adapted to these specialized environmental systems. Environmental stresses, including changes in temperature, precipitation, and fire frequency, may result in increased host plant susceptibility to insects and diseases, including both endemic and invasive species. While changes to these population and community level relationships are the subject of much conjecture, there is a growing body of examples that lend credence to the concerns for forest sustainability.

Mediterranean forests, environmental stress

All Division 7 (Forest Health) Meeting

83 - Are we doing the right things to deal with invasive forest pest and pathogens? Lessons from history

KG I - 1199 (Uni Freiburg)

IUFRO17-2172 **Management of invasive alien tree pests: Ash Dieback and Dutch Elm Disease as examples**

Vasaitis, R.* (1); Menkis, A. (1); Stenlid, J. (1)

(1) Swedish University of Agricultural Sciences, Uppsala, Sweden

Abstract: Nowadays, severe Ash DieBack (ADB) is observed in Europe. The disease is caused by invasive alien fungus Hymenoscyphus fraxineus originating from Far East Asia. It leads to massive ash mortality, and currently threatens existence of species on a continental scale. Another example of invasive alien pathogen is Dutch Elm Disease (DED), which during the last 100 years has led to massive mortality of elm trees. DED is caused by Ophiostoma fungi, originating from Asia and North America. Ash genotypes exhibit different levels of tolerance to ADB, as some trees in ADB devastated areas look healthy, despite being equally exposed to infection. Consequently, mapping and breeding/ propagation programs against ADB have been recently initiated. Also elm is is not equally susceptible to DED, and its breeding trials against DED have historical roots, and number of DED-resistant elm clones were/are developed and registered for use in horticulture and forestry. Recently, active combat measures against DED have been initiated in Gotland Island, Baltic Sea, Sweden, subjected to the most recent invasion by DED, in 2005. Gotland so far contains the largest Elm population in Europe (approx. 3mln.). To mitigate ADB & DED, the measures were initiated, as mapping and propagation of ADB-tolerant ash and DED-tolerant elm. In Gotland, active combat measures against DED currently include destroying of diseased trees and stump treatment to prevent sprouting and spread via root contacts to adjacent trees. The Project is supported by European Union Life+ Nature Project ELMIAS. Current results and further initiatives on this project will be presented.

Ash Dieback, Dutch Elm Disease, disease management

KG I - 1199 (Uni Freiburg)

IUFRO17-4049 **Ash dieback and modern techniques for resistance phenotyping**

Cleary, M.* (1)

(1) Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre, Alnarp, Sweden

Abstract: Both native and invasive forest pathogens are increasingly threatening natural and commercial forests worldwide. A key element to conserving and sustainably managing forest resources for the future, in light of these biotic threats, is to harness genetically controlled mechanisms of resistance operating in trees. To do so requires an understanding of host defense interactions of the invading organism, and the importance of genetic and environmental conditions ultimately affecting the plant phenotype. Large potential exists for utilizing modern approaches or tools that can quantitatively identify phenotypes and help explain the genetic basis of important plant traits, such as disease resistance, though such approaches still rely heavily on human expertise and/or on prognosis models. This talk will give an overview of some recent advances made in next generation plant phenotyping (metabolomics, transcriptomics), and the development of robust and reliable markers that are critical for resistance in European ash (Fraxinus excelsior) currently threatened by the alien invasive pathogen Hymenoscyphus fraxineus in Europe.

Ash dieback, resistance phenotyping

KG I - 1199 (Uni Freiburg)

IUFRO17-1087 **The importance of climatic matching in classical biocontrol of an invasive forest insect**

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Abstract: Classical biocontrol considers climatic matching with that of the pest as key criteria for selection of potential natural enemies. However, as a largely empirical field, releases into new regions are often based on effective past experiences reported for other regions, with little local adaptation of techniques and very limited new research. Focusing on the case-study of the woodwasp Sirex noctilio, likely the most important pest of pine plantations of the Southern Hemisphere, we used climate-based ecological niche models (MaxEnt) to define the potential distribution of two of its parasitoids, Megarhyssa nortoni and Ibalia leucospoides in the Southern Hemisphere, and compared our findings against data on historical releases. We found that our models predicted the establishment of both parasitoids in only part of the regions where S. noctilio invaded, and it matched those regions where parasitoids successfully established. While this is not unexpected, our findings emphasize the need for species-specific research on the ecology of natural enemies, including studies of climatic adaptation and their consequences on the interactions of parasitoids with their hosts. Such work will improve the chances for successful establishment of natural enemies in new areas, and also help predict best the outcome of classical biological control of forest pests.

Sirex noctilio, Megarhyssa and Ibalia parasitoids

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161 - Combined and interactive effects of multiple stressors on forest health

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3210 **The Connection Between Climate and Declining Forest Health in the Western United States**

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Abstract: Climate is having profound impacts on forest health in the western United States. In particular, an increasingly common occurrence of hotter droughts over the past several decades has caused advanced physiological stress, setting the stage for widespread mortality due to insects, disease, and related factors. Following earlier work with Landsat time series, we collected a large sample (tens of thousands) of time series observations across western forests using a probability design. This dataset allows for annual estimates (with uncertainties) of percent forest undergoing declines in health across the region going back to 1985. We then link these observations to climate data using stochastic antecedent modeling to discover the length, temporal pattern, and strength of drought effects on patterns of forest decline. Preliminary analyses indicate dramatic increases in forest decline across the full region beginning in the mid-1990s, with longevity of the decline signal varying by sub-region. Winter vapor pressure deficits and seasonal precipitation patterns up to three years in the past appear to influence the strength of the decline signal. Using the relationship between climate and decline we project forward to 2100 the anticipated location and timing of forest decline across the region based on different IPCC representative concentration pathways.

forest-decline, stochastic-antecedent-modeling

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1964 **Beyond Drought: Excessive Wetness, Precipitation Variance and Forest Productivity**

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Abstract: Projected increased drought and extreme wet conditions (i.e. enhanced variability) may decrease forest ecosystem productivity in many locations globally. However, there is little understanding of how increasing climate variance may affect forest ecosystem productivity. A study was undertaken in the Eastern Deciduous Forest Biome stretching from the eastern U.S. to the Midwest (mid-Missouri; the western edge of the Biome) to investigate a potential westward trend of increasing drought severity and climate variance. Overlapping climate records from 2004 through 2012 were compared between Harvard (HF) Forest (Massachusetts), Morgan Monroe (MM) State Forest (Indiana), and Missouri Ozarks (Missouri, MO) Ameriflux sites. During the growing season months of July through September, mean net ecosystem exchange (NEE, umol/m2/s) was -5.76, -3.22 and -3.52 of 2009 (extreme wetness) for HF, MM, and MO, respectively, and -4.68, -2.18, and -0.09 respectively, in 2012 (extreme drought) suggesting a westward trend of drought and wet impacts to forest productivity. An in-tandem investigation of historic climatology, Midwestern paleo climate data, and local climate influences on net ecosystem exchange and productivity will be presented, that suggest that climate variance including drought and excessive wetness should be equally considered for forest ecosystem management in an uncertain climatic future.

Forest Productivity, NEE, Climate Variance

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1831 **Multiple stressors of pine trees: Links between environmental heterogeneity, mammalian browsing and insect herbivory**

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Abstract: Trees are subject to multiple stressors. Up to now forest pests have largely been studied as separate entities despite the fact that they affect trees in an interactive way. The role of environmental heterogeneity is disputed, e.g. dead wood can function as a source of pest insects and at the same time promote generalist natural enemies.

Here we present results from studies dealing with possible links between aspects seldom previously considered together. We ask to what extent (1) mammalian browsing and (2) dead wood are linked to the control of forest insect pests, and (3) how combined mammalian browsing and insect herbivory affect tree growth.

Preliminary results indicate that both mammalian (moose) browsing and dead wood can influence the control of the insect pest under study, the European pine sawfly (Neodiprion sertifer). The links are indirect and act via bottom-up (plants) and top-down (natural enemies) processes. The combined effects of herbivory by mammals and insects on tree growth seem to be additive.

We argue that fulfilling multiple goals when managing forests are possible. For example, dead wood promotes biodiversity as well as top-down control by small mammals. However, the effect of dead wood is only expressed when proportion of pine trees in a stand is taken into account. Furthermore, mammalian browsing results in more open and less diverse vegetation, having a positive effect on top-down control via natural enemies of insect pests, either as a consequence of lower density of alternative prey or more effective enemy searching. Positive bottom-up effect on sawfly performance on trees subjected to artificial mammalian browsing could counteract changes in top-down forces.

We conclude that understanding the outcome of multiple stressors on trees needs to consider ecological interactions that sometimes act in unexpected, indirect ways. To translate such knowledge into practical and sustainable solutions, we need to identify the underlying mechanisms.

insect pest; pest control; multiple stressors;

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Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1709 **Interactive effects of ozone and soil on the decomposition process in a Free Air Controlled Exposure (FACE) system**

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Abstract: Ample scientific evidence shows that elevated levels of ozone negatively affect trees with further potential ecological consequences in the long term. However, it remains poorly understood whether and how elevated ozone impacts the core process of litter decomposition in forest ecosystems and how the type of soil affects the impacts of ozone. Communities of deciduous broadleaved and coniferous trees are growing in three different types of soil and are exposed to ambient or double ambient ozone levels, beginning in 2014, in a novel and globally unique experimental station located at the Northern island of Japan, Hokkaido. In Autumn 2016, tea bags of two types of tea were implanted in the soil of each experimental condition, following the Tea Bag Index Protocol, and an adequate sample is retrieved every few months to calculate the decomposable fraction over time. Carbon and nitrogen contents and their fraction in tea bags will be analyzed to assess the qualitative and quantitative properties over time. In order to gain a better understanding about feedback of decomposition process changes in atmosphere, content of major greenhouse gases in air released by soil is also analyzed over time. This research will contribute with significant information to advancing the understanding of decomposition process in a changing environment.

decomposition, greenhouse gas, O3, rhizosphere

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3700 **Is there a mechanistic link between aerosol pollution and drought effects on trees?**

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Abstract: Forest decline over the last 50 years has been attributed to both air pollution, leading to loss of leaf/needle area and to 'global-change-type drought', i.e. warming plus water limitation, leading to hydraulic failure of trees. Linkage between these, and any commonality of mechanism, has not been identified. There is growing evidence, however, that deposition of hygroscopic aerosols may provide such linkage, potentially exacerbating stress from increased evaporative demand and contributing to visual changes previously associated with 'wax degradation' in polluted environments.
Here, we have grown seedlings of Scots pine, silver fir, oak, and beech in greenhouses ventilated with either ambient air (AA) or filtered air (FA) removing >90% of aerosols. Ozone and other trace gases were similar. Foliage from the AA greenhouse showed amorphous structures that were absent from FA plants, visually similar to degraded waxes. Minimum epidermal conductance (gmin) of leaves, a marker of stomatal control linked to drought tolerance, was 20-30% greater in AA compared to FA plants.
These results demonstrate a direct influence of ambient aerosols on plant physiological processes. The potential role of hygroscopic aerosol deposition in linking previously disparate symptoms related to forest decline may require more detailed evaluation.

air pollution, forest decline, drought

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170 - Understanding viruses in trees - promoting healthy plants in forest and urban open space

K 8 (Konzerthaus Freiburg)

IUFRO17-924 **Birch leaf-roll disease caused by Cherry Leaf-Roll Virus in Finland**

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Abstract: Since the beginning of the 3rd Millennium *Cherry Leaf-Roll Virus* (CLRV) causes a massive outbreak called birch leaf-roll disease in birch (*Betula* spp.) trees throughout Finland. All endemic birch species and subspecies are susceptible to the virus. At the time of the best observation period from about mid-July to mid-August, symptomatic trees can be seen abundant in parks, street sides, and roadsides, but less so in forests. Number of symptomatic trees has increased gradually in the last 15 years so that, locally, up to over 70% of the trees show symptoms of birch leaf-roll disease caused by CLRV. On average about one third of the trees in birch alleys show symptoms of the disease, whereas only 0.23% of birches in the forests according to National Forest Inventory are symptomatic.

Early summer with higher-than-average temperatures improves visibility of the disease symptoms, leading to remarkable increase in necrotic foliage towards the end of the growing season. On the contrary, slightly symptomatic trees in summer one may look healthy in summer two if it is cool. Nevertheless, once a tree is infected, it seems to stay infected to its final death. The role of drivers of the disease and different modes of transmission of this generally pollen transmitted virus are discussed.

Virology, CLRV, Betula, Finland

K 8 (Konzerthaus Freiburg)

IUFRO17-502 **Viral presence in birch in urban areas - a study case from urban green of Berlin**

Landgraf, M.* (1); Langer, J. (1); Gröhner, J. (1); Zinnert, L. (1); Bandte, M. (1); von Bargen, S. (1); Schreiner, M. (2); Jäckel, B. (2); Büttner, C. (1)

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Abstract: Roadside trees as well as trees in parks and public gardens increasingly show defoliation and degeneration leading to tree felling. In Berlin biological causes of felling are predominant, whereas the proportion of storm damage, accidental and other damages is low.
Recently, viral plant diseases attracted attention as causal and/or contributing factor in the decline of trees in urban green. In early summer of 2015 and 2016 birch (Betula spp.) road side trees were inspected in Steglitz-Zehlendorf, an administrative district of Berlin. Samples were taken from tree crowns exhibiting virus-suspected leaf symptoms like mottling, chlorotic ringspots and line patterns and have been investigated by molecular biological methods (RT-PCR). The diversity of observed symptoms indicates a mixed infection.
Cherry leaf roll virus (CLRV) and Apple mosaic virus (ApMV) were identified using established protocols. New genetic information derived from NGS data enabled the detection of two non-characterized viral species of the genus Badna- und Carlaviruses. For the detection of these viruses, a method for routine diagnosis was developed and applied to investigate birch leaf material gained from diseased and asymptomatic road side trees in 2015 and 2016.

CLRV, ApMV, Carla- and Badnaviruses, RT-PCR, NGS

K 8 (Konzerthaus Freiburg)

IUFRO17-542 **Discovery of novel emaraviruses in diseased broad-leaved tree species**

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Abstract: European mountain ash ringspot-associated virus (EMARaV) is the type member of the genus Emaravirus comprising plant viruses with a segmented ss(-)RNA genome mainly infecting woody hosts. Emaraviruses consists of a core of four conserved monocistronic genome segments within the enveloped spherical particle, encoding the replicase (RNA1), a glycoprotein precursor (RNA2), the viral nucleocapsid protein (RNA3), and a movement protein (RNA4). Some members of the genus contain up to four additional genomic RNA molecules encoding proteins of unknown function. Emaraviruses have a narrow host range usually restricted to few related species. Symptoms include chlorotic ringspotting and mottling of leaves. Decline of affected broad-leaved species is also often observed.
Rowans (syn. European mountain ash) and other Sorbus spp. were assessed for EMARaV infection by visual inspection and RT-PCR. Other deciduous tree species showing virus-like symptoms were investigated for plant virus infection applying high-throughput sequencing (Illumina RNASeq) in combination with RT-PCR. Chlorotic ringspots, mottle and dieback is closely associated with EMARaV infection of the S. aucuparia population in several European countries. The virus was also detectable in other tree species of the Rosaceae family exhibiting similar symptoms. Further, previously unknown RNA viruses were identified in important tree species of other families showing chlorotic ringspots, line pattern and mottling of leaves. Sequence analyses revealed closest relationships to Emaraviruses.
EMARaV is the main viral agent which affects rowans throughout. Related plant viruses are able to infect other broad-leafed tree species in Europe and some of them are widespread in their respective host tree species. Thus, members of the genus Emaravirus have to be considered as relevant pathogens of woody species and need to be included in health management strategies of deciduous trees.

Next generation sequencing, ringspots, mosaic

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K 8 (Konzerthaus Freiburg)

IUFRO17-2328 **A new plant virus in Quercus robur - a case study of a conservation seed orchard**

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Abstract: Common oaks (Quercus robur L.) with virus-suspected symptoms such as chlorotic ringspots and spots have been described in several surveys focusing on nurseries, forest stands and urban green space since the 1990s. Some of these plants exhibited degenerated twigs and suffered from a distinct loss of vigour. So far no pathogens were determined to account for the disease.
Just recently, we identified a novel Emaravirus in an oak seedling of a gene conservation seed orchard by high-throughput sequencing. The detection of the virus is closely correlated to the observed discoloration. Oak seed orchards aim to support the conservation as well as the development of forest genetic resources provide healthy propagation material.
A long-term survey on the occurrence of plant viruses in a gene conservation seed orchard is presented. This orchard with common oak was established in 1992 in North Rhine-Westphalia with three year old seedlings (origin 817 01, provenience 'von Plettenberg/Hovestadt'). Since 1994 the 3.1 ha orchard comprising 186 taxons, was inspected and sampled at least once a year. The distribution of the characteristic symptoms in the orchard is shown over a period of 20 years and linked to the detection of the novel Emaravirus in individual trees.

Emaravirus, ringspots, survey, common oak

K 8 (Konzerthaus Freiburg)

IUFRO17-3546 **Identification of virus-like structures in conifer extracts using electron microscopy and serology**

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Abstract: Most known plant viruses have been identified and studied on agricultural and horticultural crop plants. Viruses of forest ecosystems have been much less investigated and therefore data about virus infections of forest trees are scarce.

Here we report our investigation on putative viruses infecting two conifer species, Larix decidua and Picea abies. Extracts were enriched in viral particles by differential ultracentrifugation using protocols developed for grapevine viruses. Putative viral particles were first detected by electron microscopy and consist of filamentous and isometrical structures. Polyclonal and monoclonal antibodies were raised in rabbit and mouse against such extracts (Gugerli, unpublished results). These antibodies reacted with the putative particles using immuno-precipitation electron microscopy (IPEM). They also reacted in enzyme-linked immunosorbent assays (ELISA) with various conifer extracts.

Evidence shows that the observed structures are made of proteins and nucleic acids (i.e. RNA). It is assumed that they represent viral nucleoproteins and graft transmission will be undertaken to demonstrate their infectious nature. In order to get more details about the nature of those pathogens, molecular characterization has been initiated. Recent advances in high-throughput sequencing technologies have facilitated the way of obtaining sequence information. Small interfering RNAs isolated from two Larix trees were analyzed using next generation sequencing performed by the Illumina platform. However, it was not possible to identify viral sequences using this approach. Alternative NGS strategies including RNAseq and deep sequencing of virus-like particles nucleic acids will be evaluated for conifer virus discovery.
Altogether, our data suggest the presence of multiple virus infection in conifers. Although chlorotic symptoms and reduced vigor were observed, more biological and epidemiological data are needed to address the effect of these viruses on conifer.

conifer, virus

K 8 (Konzerthaus Freiburg)

IUFRO17-535 **Mycoviruses in important tree pathogens**

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Abstract: Mycoviruses are ubiquitous intracellular inhabitants of fungi - including forest pathogens. Their biocontrol potential has been demonstrated on Chestnut blight, which has been successfully controlled in Europe for decades. We have shown that several important forest pathogens of conifers host diverse virus communities: i.e. Gremmeniella abietina, Fusarium circinatum, Phytophthora cactorum and species of the Heterobasidion complex. The best known of these are the viruses of Heterobasidion species, which are able to spread over species borders within this complex, and occasionally even between taxonomically distant fungi. Locally, the diversity and frequency of these viruses increases in time suggesting that virus load might contribute to the age of Heterobasidion clones. Viral co-infections are common, and may affect the spread of viruses among fungal mycelia. Most Heterobasidion viruses do not cause obvious effects on their hosts, although some do have phenotypic effects. Single virus strains may have contrasting effects depending on host strain and the trait tested. Therefore it is often difficult to decide whether a given virus is beneficial, cryptic or mutualistic to its host. However, one Heterobasidion partitivirus causes a serious disease on the host fungus, restricting its mycelial growth and altering the gene expression considerably. This potential biocontrol agent has been tested on forest trees with promising results.

Root rot, virus diversity, biocontrol

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K 8 (Konzerthaus Freiburg)

IUFRO17-1369 **The frequent occurrence of the quarantine pest organism Candidatus Phytoplasma ulmi in North-Eastern Germany**

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Abstract: *Ulmus minor*, *Ulmus glabra* and *Ulmus laevis* represent key ecological species in forests, fields and wetlands. While the incidence of *U. minor* and *U. glabra* has decreased dramatically due to *Ophiostoma novo-ulmi*, the first report of another elm pathogen in *U. glabra* in Germany (1993), the causative agent of the elm yellowing *Ca.* Phytoplasma ulmi, has been recognised. This bacterial parasite was responsible for several outbreaks in the US, resulting in regional elm losses of up to 58% in just a few years. Disease symptoms include yellowing, witches' broom formation and necrosis of the phloem, resulting in the decline and death of elms. The pathogen is classified as a quarantine pest in Europe (A1) but is present in several countries. In *U. laevis*, infection was reported in the south of the Brandenburg district (2014-15), and so additional samples were taken in 2016 to estimate if infections occur frequently in this important region for elms.
U. laevis (N65) and *U. minor* (N6) were sampled during early summer in Märkisch-Oderland (E-Brandenburg). Eight samples were obtained from *U. laevis* in Schleswig-Holstein (NW-Germany). None of the *U. laevis* trees showed phytoplasma-associated symptoms, while *U. minor* showed symptoms of Dutch elm disease. Leaf midribs were selected for DNA extraction and DNA was used for phytoplasma diagnosis by applying family-specific universal primers in direct and nested PCR. Products were then sequenced and analysed.
Ca. P. ulmi infection was detected in 21 *U. laevis* samples obtained from Märkisch-Oderland (32%) but not in the samples originating from Schleswig-Holstein or in *U. minor*. Results from this study and previous studies indicate that Ca. P. ulmi is established and widely distributed in *U. laevis* stands in Brandenburg. Extensive sampling in 2017 will help clarify if this phytoplasmoses is also present in *U. laevis* in other parts of Germany and other elm species.

Phytoplasma ulmi, Ulmus, Germany

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IUFRO17-1162 **Challenges to Managing National Parks for Biodiversity and Ecosystem services under natural disturbances: Lessons from Bavarian Forest Nationalpark**

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Abstract: Increasing natural disturbances in conifer forests worldwide complicate political decisions about appropriate land management. In particular, allowing insects to kill trees without intervention has intensified public debate over the dual roles of strictly protected areas to sustain ecosystem services and to conserve biodiversity. Decades of research from the oldest large scale affected national park in Europe, provide lessons about disturbance effects on all major ecosystem services, e.g. drinking water, recreation values, and biodiversity of mountain forests. In contrast to the public debate, visitors appreciate the rewilding of former production forests, the maximum nitrate concentrations in runoff used for drinking water increased significantly but only temporarily at the headwater scale. Moreover, this major criterion of water quality remained consistently far below the limit recommended by the World Health Organization. Biodiversity, including numbers of threatened species, increased for most taxa across a broad range of lineages. Hence, these studies provide strong support for a policy to allow natural disturbance-recovery processes to operate unimpeded in conifer-dominated mountain forests, especially within protected areas.

Ips typographus, Mountain forests

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IUFRO17-662 **A global analysis of recent disturbance patterns in temperate forest ecosystems**

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Abstract: Natural disturbances in temperate forest ecosystems are expected to change drastically within the 21th century, yet the patterns and drivers of disturbances remain incompletely understood. To better understand disturbances and provide a baseline for future disturbance change, it is important to quantify recent disturbances and their within-biome variation. Until recently, however, such large-scale analyses were limited by a widely varying availability and quality of disturbance data. In recent years, much progress has been made in the remote sensing of forest change. Yet, anthropogenic and natural disturbances cannot be distinguished in currently available datasets, limiting their ecological interpretation. To overcome this limitation and consistently contrast the patterns of natural disturbances with those in coupled human and natural systems, we - together with a consortium of global disturbance experts (see http://resin.boku.ac.at/page/global-disturbance-patterns) - focused on 52 strictly protected areas in the temperate forest biome, distributed across five continents and representing a total area of ~6,450 000 ha. Our objectives were to quantitatively describe recent disturbance patterns (e.g. occurrence, size, and shape), identify factors explaining within-biome variation in disturbance, and contrast this variation with the differences between protected areas and their managed surroundings. Our results indicate that differences in the locally prevailing disturbance agents are important for explaining variable disturbance patterns across the globe. We found that host-specific disturbance agents such as insects and pathogens create significantly more complex spatial patterns than disturbances affecting all trees. Additionally, topographic complexity and climatic extremes affected disturbance occurrence. While disturbance regimes differed within and outside protected areas, the large-scale differences across the biome were more pronounced than management effects.

bark beetle, fire, wind, questionnaire

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IUFRO17-984 **Microbial interactions with insect disturbance**

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Abstract: Tree mortality caused by mountain pine beetle (Dendroctonus ponderosae) is rapidly transforming western North American landscapes. By studying the belowground ecology of beetle-killed forests through a combination of field and greenhouse experiments, we have shown that the legacy of the mountain pine beetle extends far beyond a single cohort of trees. In particular, high levels of tree mortality change the composition of soil fungi. Fungi forming ectomycorrhizas, and dependent on living hosts for sugars, decrease in presence while saprophytic and pathogenic fungi tend to increase in soils of beetle-killed stands. These shifts in fungal community composition, in turn, affect the next generation of pine seedlings. Pine seedlings grown with fungi from beetle-killed stands have lowered defense chemicals compared with seedlings grown with fungi collected from undisturbed stands. Pine seedling survival in the field is also lower in beetle-killed than undisturbed stands. Taken together, our research demonstrates that mountain pine beetle may indirectly affect the next generation of pine seedlings through disrupted belowground mutualisms. Such far-reaching cascading effects emphasize the interconnectedness of seemingly discrete components of forest ecosystems.

pine, ectomycorrhizas, tree mortality

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IUFRO17-2019 **Ecological, social, and institutional dimensions of using wildfire to manage fire regimes**

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Abstract: Federal land managers of the United States are tasked with managing forests that have been altered as a consequence of decades of fire exclusion, logging, continuing fire suppression, and a changing climate. Vegetation and fuels can be actively managed with prescribed fire or non-fire techniques, but these methods are infeasible for a substantial portion of federal lands, and there is an urgent need to opportunistically use wildfires to manage fuels at landscape scales. An expertise has developed in wilderness, where fire management strategies include intentionally allowing wildfires to burn for their ecological benefits. Some wilderness areas have been successfully implementing this strategy for over forty years, providing useful lessons about the ecological, social, and institutional dimensions of managing fire regimes.
Numerous studies of naturally burning wildfires in wilderness have provided a solid ecological justification for expanding the opportunistic use of wildfire beyond wilderness. However, the practice is limited by numerous social and institutional barriers. Although policy provides the flexibility to expand the use of wildfire, managers lack incentives to do so, and they often lack the advanced training and skilled staff required. The immediacy of the decision time frame for wildfires focuses attention on short term risks, which encourages decisions to suppress. Complexities of climate change and an expanding wildland-urban interface further dis-incentivize managers.
Risk assessments are increasingly being used to support fire management decisions. In concept, the risk framework allows the benefits and costs of wildfires to be weighed against the benefits and costs of suppression, and new spatial risk analysis tools are being adapted to identify opportunities for allowing fires to burn. In practice, however, it remains to be seen whether such advances in risk analysis will alter how risk is perceived and the choices ultimately made by managers.

wilderness, fire management, risk

KG I - Aula (Uni Freiburg)

IUFRO17-1580 **Interactions among population regulating agents, time delays, and defoliator outbreaks in a changing landscape**

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Abstract: Insect outbreaks in northern forests of Europe and North America have recently been increasing in magnitude and severity. Host plant quality plays an important role in determining the performance of herbivorous insects. Synchronised emergence of insects from diapause in the spring with bud burst phenology of their hosts is crucial to successful completion of their life cycles, particularly in climates where summers are short. In response to a warmer climate, changes in phenological synchrony have consequences on outbreak behaviour of forest insects in northern latitudes. Consequences include shifts on to new or secondary host species, changes in life history traits, range expansions, and changes in disturbance patterns. Using the spruce budworm as our model system, we discuss the cascading effects of phenological changes in host trees on: insect herbivory, effect of natural enemies, changes in forest composition and ecosystem productivity. We predict that northern ecosystems in which host trees have not co-evolved with severe disturbance regimes could suffer from impacts on resilience and stability. We therefore need to improve our understanding of climate-driven impacts on complex ecosystem interactions. Forest management strategies should take into account thresholds for ecosystems beyond which changes due to severe disturbance may not be easily reversible.

population dynamics, hosts, enemies, resilience

KG I - Aula (Uni Freiburg)

IUFRO17-897 **The last giant Araucaria angustifolia trees in southern Brazil**

Callegari Scipioni, M.* (1)

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Abstract: Araucaria angustifolia is a native tree species of major importance in southern Brazil. It is a regional symbol for its iconic shape in the landscape, its wood was responsible for an important economic cycle and its seeds are used in regional cooking. Despite its importance and apparent abundance, the species is threatened with extinction caused mainly by the disorderly exploitation together with the deforestation. The largest trees were the first to be extracted from forests with a large population imbalance. The largest trees were the first to be extracted from forests with a large population imbalance. The relevance of the study in cataloging them is due to the lack of knowledge and its rarity. In addition to the potential of these trees for the development of autoecology of the species for its conservation allied to nature tourism. The cataloging was based on trees with more than 2 m in diameter measured in loco. The location of research and measurement lasted three years. The results demonstrate the existence of only 13 large individuals. The largest Araucaria is in the state of Santa Catarina with 3.25 m in diameter and estimated age may exceed 1,500 years.

Big tree; old growth forest, Araucaria Forest

All Division 7 (Forest Health) Meeting

120 - Insect pests and pathogens of tree reproductive structures in a changing world: assessing

K 8 (Konzerthaus Freiburg)

IUFRO17-2859 **Pest management in seed orchards based on monitoring**

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Abstract: Trees derived from seed orchard seeds grow faster than trees originating from seeds collected in local forests, resulting in increased income and land value for forest owners as well as increased carbon sequestration. Several insect species feeds on cone and seeds. In Sweden, the four most serious species are Cydia strobilella, Dioryctria abietella, Eupithecia abietaria and Strobilomyia anthracina. Due to different flight periods, spraying might be more effective if adapted to each species. To test this, untreated control (C) and four treatments of alphacypermethrin were used: S1, Spraying at early flight of C. strobilella (and S. anthracina). S2, spraying at early flight of D. abietella (and E. abietaria). S3, in mid-August against D. abietella. S4, spraying at all three occasions. There was significant reduction of C. strobilella by treatment S4 (S1 close to significant) than other treatments. The average number of larvae per cone was lower in these treatments compared to C. Spraying at S2-S4 significantly reduced damage by D. abietella/E. abietaria compared to C. The treatments S1 and S4 had a tendency of lower damage by S. anthracina than C. In conclusion, insecticide effective by contact showed promising result and should be further evaluated at different crop size and insect densities.

Norway spruce, pest management, monitoring, IPM

K 8 (Konzerthaus Freiburg)

IUFRO17-942 **The ecology of pre-dispersal seed predation by forest insects**

Boivin, T.* (1); Candau, J.-N. (2)

(1) INRA, Avignon, France; (2) NRC Canadian Forest Service, Sault-Sainte-Marie, Canada

Abstract: Plant-insect interactions have provided for decades many ways to understand how some species affect the distribution, the abundance, and the evolution of others. Because they affect the number of viable seeds available for plant recruitment, seed predators have received considerable attention from ecologists for the influence they may have on plant demography, spatial distribution, diversity and evolution. Insects are considered the most important seed predators during the pre-dispersal phase of seed development. Compared to other organisms, the success of insects in the exploitation of the pre-dispersal niche primarily rely on their flexibility in synchronizing their life-cycles with the ephemeral availability of seeds on their host plant, and on evolved strategies for coping with the highly variable and unpredictable resource that seeds represent in both space and time. Here, we will review the ecological implications of insect pre-dispersal seed predation in forest ecosystems. Considering both the insect's and the tree's perspectives, we will discuss how tree-insect seed predator interactions illustrate key mechanisms of animal-plant relationships and their consequences on ecosystem functioning. Addressed issues include diversity and guild structure in forest seed insects, host plant specialization, spatial and temporal dispersal, and the demographic and genetic implications of seed predation for tree populations, including those experiencing contrasting effects of climate change.

Masting, specialization, insect-plant interactions

K 8 (Konzerthaus Freiburg)

IUFRO17-3660 **Cone insect monitoring: pheromone trap height in spruce seed orchards**

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Abstract: *Dioryctria abietella* (Lepidoptera: Pyralidae) and *Cydia strobilella* (Lepidoptera: Tortricidae) lower seed production in Norway spruce (*Picea abies*) seed orchards in Finland. The infestation rates of the two species vary from 10 or 80 percent from year to year. Present day seed orchard management calls for an intergrated pest management approach. Therefore, functionality of pest monitoring using pheromone traps was tested.

Initially, white delta traps baited with synthetic female pheromones were set at height of 1.5 m in seed orchards. The trap captures were low despite the high damage rate observed in the cones. As the flowers and cones grow in the upper part of the tree crowns, different trap heights (1.5 m, 3 m, 6 m, 9 m and 14 m) for both *D. abietella* and *C. strobilella* were tested in an old and a young spruce seed orchard where the tree tops reached 16 - 19 m and 7 - 9 m in height, respectively.

In the old orchard *D. abietella* males were caught mostly at 14 m, only some at 9 m and none at 1.5 m. *C. strobilella* males were equally attracted to traps at 1.5 m and 14 m but *C. strobilella* catch at 9 m was more than double the catch at 1.5m and at 14 m.

In the new orchard the highest catch of *C. strobilella* was at 9 m and almost zero at 1.5m. *C. strobilella* was not caught above the canopies and, in addition, only few *D. abietella* males were found at 14 m. *D. abietella* catch at 9 m was low and the catch at 1.5 m was four times higher than the one at 1.5 m. Finally, comparisons among trap heights of 1.5 m, 3 m, 6 m and 9 m revealed that highest trap captures for both species were at 6 m.

For now, no rule of thumb for monitoring height exists. More knowledge is needed on the correlation of the damage rates and trap captures in space and time. In conclusion, *D. abietella* tend to fly and be attracted to pheromones higher than *C. strobilella*.

IPM, tree seed production, seed predator, moth

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120 - Insect pests and pathogens of tree reproductive structures in a changing world: assessing

K 8 (Konzerthaus Freiburg)

IUFRO17-3053 **Messing with megagagametophyte gene expression allows a seed parasite (Megastigmus spermotrophus) to harness the storage reserves of its host, Douglas-fir.**

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(1) University of Victoria, Forest Biology University of Victoria, Victoria, Canada

Abstract: Douglas-fir seed is susceptible to a parasitic chalcid wasp that lays its eggs into megagametophytes during a period corresponding to central cell and egg maturation, i.e. immediately before and during fertilization. Whether a conifer egg aborts or is fertilized, the megagametophyte that houses the eggs never aborts: instead, it is manipulated by the larva. Four types of ovules/seeds were studied: 1. pollinated and uninfested, 2. pollinated and infested, 3. unpollinated and uninfested, and 4. unpollinated and infested. A de novo reference transcriptome was assembled in Trinity. Expression values were estimated based on the alignment of the original reads back onto the reference transciptome using RSEM. Transcripts were annotated based on sequence similarity to genes of Pinus taeda, Arabidopsis thaliana, Nasonia vitripennis, and the UniProt database. Differential gene expression in Douglas-fir suggests that M. spermotrophus is capable of manipulating its host. Infested treatments had more transcripts related to seed storage, cell division and growth, solute transport, programmed cell death and hormone signaling that were similarly expressed in pollinated than unpollinated seeds. Although larval feeding triggers some genes involved in wounding, defense genes against herbivory are not up-regulated, meaning the insect achieves an uncontested access to the seed's storage reserves.

Douglas-fir, seed parasite, gene expression

K 8 (Konzerthaus Freiburg)

IUFRO17-880 **Early detection of invasive seed chalcids (Megastigmus spp.) through extensive surveys in major European botanical gardens: the example of rose seed chalcids**

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(1) INRA, Zoologie Forestiere, Orleans, France

Abstract: Botanical gardens at Paris National Museum of Natural History and Kew were sampled during 2013-2015 for hips of wild roses, Rosa spp., in order to check the possible presence of seed consumers on the shrubs planted in these urban areas. Depending on the year, the survey concerned 19- 32 species in Paris and 56-70 in Kew. More than 50000 seeds were X-rayed of which 13-28% were infested by insect larvae in Paris but ca. 6% in Kew. Besides Megastigmus aculeatus, a native seed chalcid present in the surroundings of both sites, adult emergence revealed the additional infestation by 4 alien species of Megastigmus which were not recorded until now in these regions. Two species, confirmed by molecular analyses, originated from North America, one from Eastern Europe, the origin of the last one being yet unknown. The exchange/trade of seeds is the most likely pathway. The presence of a large set of rose species also allowed to test for specificity of chalcids in relation to botanical sections within the genus Rosa. Gardens and arboreta thus proved to constitute a tool for early detection of alien seed insects. The study is expected to be extended to other gardens and arboreta of Eurasia, and to tree and shrub species

Rosa, seed, seed chalcid, invasion

K 8 (Konzerthaus Freiburg)

IUFRO17-2355 **Cone and seed insects-mediated impacts of global change on forest health: observations, predictions, and management options.**

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Abstract: The vast majority of the scientific literature on the interactions between global change and forest pests has focused on insects that are directly or indirectly affecting tree survival. In comparison, the interactions with insects affecting tree reproduction, particularly cone and seed insects, have received little attention although seed availability is likely to severely constrain the response of tree populations to climate change. The current state of knowledge suggests that cone and seed insects can have unexpected impacts on the ability of tree populations to respond to a changing environment. Indeed, recent results show that insects can limit the spatial migration of forest tree populations hindering their capacity to track ecological niches as the environment is changing. The alternative strategy for persistence of tree populations under climate change, i.e. the adaptation to new conditions in current locations, can also be affected by insect seed predation although the mechanisms of interactions are even less well understood. We argue that our capacity to predict how these insects will respond to and interact with climate change is hampered by the shortage of information on their long-term impacts on the functioning and sustainability of forest ecosystems. In this presentation we will review how cone and seed insects are expected to respond and interact with climate change, how some of the complex interactions between these insects and climate change are already observed and what are the information gaps that limit our capacity to predict their future impacts. Finally, we will discuss a number of considerations in the management of these insects in a changing climate.

cone and seed insects, climate change, adaptation

All Division 7 (Forest Health) Meeting

192 - Global decline of Fraxinus species caused by invasive pests and pathogens

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2707 **Can we predict the evolutionary trajectory of the ash dieback pathogen in Europe based on its biology and ecology?**

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Abstract: Hymenoscyphus fraxineus (synonym H. pseudoalbidus; anamorph: Chalara fraxinea) is an invasive fungal pathogen causing massive ash dieback and tree mortality on Fraxinus spp. in Europe, especially on common ash F. excelsior. The disease was initially observed in Eastern Poland and subsequently spread almost through the entire distribution range of F. excelsior in Europe. Recently, H. fraxineus was discovered in several East Asian countries where it occurs on F. mandshurica and F. chinensis ssp. rhynchophylla. Population genetic studies with microsatellite markers revealed a severe founder effect among European strains consistent with the characteristics of an introduced species. In contrast, populations from Japan harbored a high genetic diversity indicating the native range of the fungus. Compared to other invasive forest pathogens H. fraxineus revealed quite a unique biology. The fungus spreads exclusively by wind-dispersed ascospores and, unlike other pathogens, apparently does not make use of clonal distribution. The pathogen usually infects ash trees via their leaves from where it grows via the petiole into the twigs and branches. Infections are not systemic and mature trees usually survive several years depending on their level of tolerance. After more than two decades of research about ash dieback in Europe many important questions about the disease and the pathogen are answered. Nevertheless some important details about the biology of H. fraxineus remain unsolved and some new questions arose. Probably the most important and interesting one is how the pathogen will evolve in the invaded area in the future. Will the pathogen increase or decrease its virulence and what will happen if additional genotypes are introduced from the native range of the pathogen? Using the current knowledge about the biology and ecology of H. fraxineus, possible evolutionary scenarios are presented and, at the same time, important knowledge gaps will be uncovered.

biology, evolutionary ecology, ash dieback, pathog

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-453 **Population genetic analysis of a parasitic mycovirus to infer the invasion history of its fungal host, the ash-dieback pathogen Hymenoscyphus fraxineus**

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Abstract: Hymenoscyphus fraxineus is an introduced plant pathogen responsible for the devastating ash dieback epidemic in Europe. Recently, we described Hymenoscyphus fraxineus mitovirus 1 (HfMV1), which occurs in this introduced fungus. Here, we explored the prevalence and genetic structure of HfMV1 in order to elucidate the invasion history of both the virus and the fungal host. To do so, a total of 1298 H. fraxineus isolates (both from Europe, as well as from Japan, as an Asian origin of the fungus is assumed) were screened for the presence of this RNA virus. Subsequently, 301 virus-positive isolates were subjected to partial sequence analysis of the viral RNA polymerase gene. Our results indicate a high mean prevalence (78.7 %) of HfMV1 across European H. fraxineus isolates. This suggests an efficient spread of the virus, probably through sexual spores of its host. Furthermore, only 1.1 % of the Japanese isolates were tested virus positive. This is in accordance with an expected founder effect in the introduced fungal population in Europe. In Europe, HfMV1 shows low nucleotide diversity but a high number of haplotypes, which seem to be subjected to strong purifying selection. Phylogenetic and clustering analysis detected two genetically distinct HfMV1 groups, both present throughout Europe. This pattern supports the hypothesis that only two (mitovirus-carrying) H. fraxineus individuals were introduced into Europe as previously suggested from the bi-allelic nature of the fungus. Moreover, our data points to reciprocal mating events between the two introduced individuals, which presumably initiated the ash dieback epidemic in Europe.

H. pseudoalbidus, Chalara fraxinea

All Division 7 (Forest Health) Meeting

192 - Global decline of Fraxinus species caused by invasive pests and pathogens

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-804 **Fourier-transform infrared (FT-IR) spectroscopy can rapidly phenotype European ash resistance levels to Hymenoscyphus fraxineus**

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Abstract: Ash dieback (ADB) is a lethal disease of European ash (Fraxinus excelsior) caused by the invasive ascomycete Hymenoscyphus fraxineus. While the pathogen continues to spread throughout Europe, decimating the majority of ash trees, a small proportion of plants appear to survive even in highly affected areas, suggesting the presence of some level of resistance that could be exploited for management. However, the lack of tools for rapidly phenotyping trees strongly limits the effective use of resistance for conserving the species. We used Fourier-transform infrared (FT-IR) spectroscopy, a chemical fingerprinting technique, to rapidly phenotype ash genotypes resistant or susceptible to ADB. Leaves and shoot samples from trees that had been previously characterized in terms of resistance (the training set) were collected from six European countries, covering a broad geographic area. Phenolic extracts from these tissues were analysed with FT-IR, and soft independent modelling of class analogy (SIMCA) was used to discriminate between resistant and susceptible trees. While models built with leaves showed little power, the ones built with bark samples from shoots were very powerful, indicating that FT-IR can clearly discriminate between phenotypes displaying contrasting resistance levels to ADB. Furthermore, SIMCA models were validated using a separate set of completely blind samples (the testing set), strengthening our results. The implementation of FT-IR for resistance phenotyping holds real promise for the endeavours to conserve European ash.

ash dieback, resistance, FT-IR, rapid phenotyping

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1813 **Emerald ash borer in European part of Russia: 2016 situation update**

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Abstract: EAB or emerald ash borer Agrilus planipennis Fairmaire (Coleoptera, Buprestidae) - an aggressive Far Eastern invader was registered in Moscow (Russia) in 2003 with its' taxonomic identification in 2005. Prior to that - in 2002 - EAB was found at Northern America where it quickly became a pest No. 1, eliminating millions of trees from 16 species of genus Fraxinus. Up to the end of 2016 it was found in 29 USA states and in 2 provinces of Canada. Nowadays in Europe EAB infests ash trees in 11 administrative regions of the Russian Federation.
By methods of dendrochronological cross dating we proved the existence of EAB in the city of Moscow from 1997, at the southern part of Moscow District (Puschino) from 2009, at the Western border of EAB's secondary range (city of Vyazma) from 2010 and at the Southern border (city of Voronez) - from 2006. The western front of EAB invasion has moved with the speed of 12 km per year.
During last 3 years EAB nearly disappeared from the city of Moscow and its' suburbs although many damaged ashes are still alive and are regenerating successfully. Existing data demonstrated that EAB outbreak collapse was caused in major extent by local polytrophic parasitoids from genus Spathius Nees (Hymenoptera: Braconidae) who have switched to the new abundant host.
We have now a unique example when local biota only during a quarter of a century assimilated populations of the aggressive invader - emerald ash borer. It generates some optimistic expectations about the future of ash species in Europe.
The work was supported by the Russian Foundation for Fundamental Research (grant 17-04-01486).

Emerald ash borer, Russia, outbreak collapsed

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192 - Global decline of Fraxinus species caused by invasive pests and pathogens

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2375 **Factors influencing susceptibility and rate of decline in urban trees attacked by emerald ash borer**

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Abstract: Emerald ash borer (EAB) is the most significant threat to ash trees in eastern North America. However, there are few tools available to urban forest managers to help predict the likelihood that a tree will be attacked by EAB, and once it is attacked the rate at which the tree will decline. EAB can detect differences in the quality of potential hosts, and small populations of the insect can suffer high mortality in well-defended trees. Anecdotal evidence suggests that not all trees in all urban plantings are attacked at the same time or decline at the same rate once attacked. This study had three objectives: 1) Determine which abiotic and biotic factors that best predict a tree's susceptibility to attack; 2) determine which factors predict the rate of decline once a tree is attacked and; 3) determine how a survivorship and longevity is impacted when a control measure is applied. Between 2010 and 2015 we identified and surveyed ca. 500 ash trees in five communities in Ontario, Canada. These trees were located in cities known to have EAB infestations, but in neighbourhoods not yet subject to high levels of EAB attack. The period of observation coincided with increased abundance of EAB in each community. Every year we recorded metrics of each tree's growing condition, quantified signs and symptoms of attack, and if the tree was treated with insecticide to control EAB. We then used machine-learning techniques to select among competing criteria to select the variables that best predict susceptibility and rate of decline. To evaluate the effect of a control tactic we paired treated trees with untreated trees and examined which factors influenced susceptibility and the longevity of trees after treatment. The goal of this study is to derive objective thresholds and criteria to help managers decide if the value of a tree is worth the cost required to save it by incorporating information about susceptibility into their decision making process.

emerald ash borer; management; urban forestry

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2044 **Progress and gaps in understanding mechanisms of ash tree resistance to emerald ash borer**

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Abstract: We present a review of the literature, as well as more recent results, on mechanisms of resistance of ash to emerald ash borer, an invasive wood-boring insect causing widespread mortality of ash in North America. Manchurian ash, which coevolved with EAB, is more resistant than evolutionarily naïve North American and European congeners. Such resistance is expressed as lower preference by adults for feeding and oviposition as well as significantly lower larval development in Manchurian ash. Consistent with EAB being a secondary colonizer of coevolved hosts, drought stress decreases resistance of Manchurian ash, but appears to have no effect on specific constitutive bark phenolics, suggesting that, on their own, phenolics do not contribute to intraspecific variation of resistance. Instead, converging evidence from multiple studies of host and insect oxidative enzyme activities suggest that a more oxidative environment in Manchurian ash is a key aspect of resistance to EAB. Transcriptional profiling of resistant and susceptible ash species before and after EAB larval feeding is shedding light on the genetic basis of candidate constitutive and induced resistance genes, including those involved in the synthesis of PR-10 proteins, phenolic biosynthesis and those coding for pro-oxidant enzymes.

Emerald ash borer, host resistance mechanisms

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KG I - 1010 (Uni Freiburg)

IUFRO17-878 **An Overview of the Role of Forest History & Cultural Heritage in Re-constructing Nature at a Landscape Level**

Rotherham, I.* (1)

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Abstract: It is increasingly clear that worldwide, forest and woodland landscapes have suffered dramatic changes and drastic declines during the twentieth century. However, in the early twenty-first century there has been growing recognition of the need for major and large-scale remediation of such declines and the consequent environmental, social and economic impacts (Rotherham, 2013a). Increased awareness of the significance of the bio-cultural nature of forest and woodland resources has challenged many conceptual positions (see Rotherham, 2015, Agnoletti & Rotherham, 2015). This has begun to trigger changes in policy directions and national and international levels, and whilst major international policy tools such as the European Landscape Convention (2000) have the potential to recognise and take into account the eco-cultural nature of landscape and the bio-cultural nature of much heritage. In this context, the processes of 'cultural severance' (Rotherham, 2008; 2013b) kick in with global implications at local and regional levels (Rotherham, 2011a), and the loss of traditional knowledge can be a serious problem (Rotherham, 2007).

Understanding the history, heritage and bio-cultural nature of landscape has proved increasingly important in better informing effective and sustainable re-construction projects, but with increasing awareness that the 'cultural' element is frequently omitted and that this has serious implications (Rotherham, 2011b). The impacts of cultural severance and the implications for forest management have been discussed (Rotherham, 2012; 2013a).

This paper provides an overview of key issues with innovative models and cross-disciplinary approaches. Case study examples are presented to illustrate the processes and to test the conceptual models.

References

e.g.
Rotherham, I.D. (2015) Bio-Cultural Heritage & Biodiversity - emerging paradigms in conservation and planning. Biodiversity & Conservation, 24, 3405-3429.

cultural severance eco-cultural biocultural forest

KG I - 1010 (Uni Freiburg)

IUFRO17-381 **Concepts of Landscape Restoration in the History of the Alpine Region of Austria**

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Abstract: The ongoing degradation of the world's forest land has led to renewed interest in the history of countries where tree-based landscape restoration was carried out successfully. What factors contributed to landscape degradation and what measures were taken to reverse the direction of change? Can lessons be learned from the experience? Forest managers, scientists and politicians often lack the necessary information to integrate the present situation in a long term historical context. Therefore, case studies are necessary to improve the knowledge of long-term historical changes in landscape development. Thereby the scientific value of a singular case study is less important than the illustration of its linking.
In Austria about 500.000 hectares of degraded land existed at the turn of the 19th/20th century. When the area extended, the population suffered from various natural hazards. This was the reason why landscape restoration turned to the most important question of that time. It was a chance to stop the stream of migration and to safeguard the means of the population's subsistence. The restoration of the landscape and the preservation of the biocultural heritage were considered as a peaceful conquest of the land with the arms of the plough.
In this paper, some of the anthropogenic components being responsible for the degradation are investigated. The main focus is put on the societal perception of the environmental impact and people's increasing awareness. It addresses the debate concerning the afforestation of wasteland taking into account social, ecological, ethical, and strategic aspects. The authorities as well as the technicians working in the field were entirely aware that the success of the afforestation works depended to a considerable degree on the participation of the local people. Therefore, laws and supervision were less effective than the implementation of socially balanced cultivation plans taking into consideration the local needs and interests.

wasteland, afforestation, landscape restoration

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145 - The Role of Forest History & Cultural Heritage in Re-constructing Nature - a landscape-level

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IUFRO17-2293 **Historical tree species composition and forest habitat continuity are important determinants for carbon stock in topsoils and subsoils in a large forest patch of north-eastern Germany**

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Abstract: Past land use is a well-known determinant of patterns and processes in current ecosystems and may have long-lasting effects for decades, centuries or even millennia. In particular, the global carbon balance has been linked to worldwide historical land use (Houghton, 2003). Land-use legacies have been found in several components of ecosystems, e.g., in the vegetation (Foster et al., 2003) and in the soils (Dupouey et al., 2002). Land-use legacies are likely to be revealed in forests, as they are composed of long-lived plant species and thus represent a more-or-less persistent land cover type. For example, studies have shown greater carbon (C) sequestration in ancient vs. recent forest ecosystems (habitat continuity of >200 or < 150 years, respectively) (Koerner et al., 1997; Leuschner et al., 2013, 2014).
We have reconstructed the tree species composition for a landscape in north-eastern Germany (Wulf et al. 2016, doi: 10.1093/forestry/cpw061), and in particular we have focussed on a larger forest called the "Templiner Buchheide" covering 773 hectare. In this forest we have distinguished between ancient (forest continuity >200 years) and "old" (forest continuity >120, but <150 years) forest sites, and between beech, oak and pine dominated stands in order to answer the questions (i) whether there are significant differences in carbon stocks between ancient and old (mainly formerly used as grasslands) forest sites, and (ii) between the three tree species? Moreover, we wanted to find out whether there are significant differences between topsoils and subsoils? Our results show significant differences in carbon stock between ancient and old forest sites independent of the tree species, but a clear increase in carbon stock with soil depth for beech and pine, but not for oak. The results reveal the importance of a careful reconstruction of the tree species composition using various archival sources and forest habitat continuity using historical and actual maps.

ancient forest, beech, oak, pine, carbon stock

KG I - 1010 (Uni Freiburg)

IUFRO17-1493 **Cultural and scientific heritage of forest history and its recent and future significance - interconnecting forest history, science and people**

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Abstract: Historical activities and knowledge are of great importance for both (1) the tradition of the local people, their identity and identification with forests and landscapes, and (2) different fields of science - studying traditional land use practices and forest history has social, economic and ecological dimensions. Within a transdisciplinary research project (Real-world Laboratory "Knowledge Dialogue Northern Black Forest") we study selected questions of land use and forest history closely related with the local people. Wood charcoal production was one of the most important and frequent activities. For example, that applies especially to remote areas of the first nationalpark of Baden-Wuerttemberg in the Black Forest. Charcoal burning sites (CBS) with distinct structural features of the ground surface as well as charcoal macroremains preserved at these sites, contain comprehensive information about the historical forests exploited and the human influences therein. Therefore CBS studies are a main key for high resolution forest and landuse history at the stand-scale level of consideration. Unfortunatelly such sites generally are not recorded in written sources or in historical maps and they are not visible in the common aerial photographs. Usually time-consuming field work is necessary to record their exact geographical position. Aiming on a reduction of the field work and on the visualization of the spatial dimension of these historical activities on a landscape level but with fine spatial resolution, in our study we use two additional approaches, (1) the knowledge of the local citizen of the regions (oral history) as well as (2) airborne laser scanning (LiDAR). Thousands of indications to potential CBS have been provided by these "tools", of which a very large number already have been evaluated successfully by field survey. The results are used to save the traditions and to establish additional scientific studies and results, e.g. by anthracological analyses.

charcoal production, tradition, transdisciplinary

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IUFRO17-1593 **Using historic maps and citizen science to investigate the survival of old survey 'blaze' trees**

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Abstract: This study investigated the occurrence and condition of survey reference trees in remnant native vegetation in southern New South Wales, Australia. A citizen science method, in conjunction with a systematic examination of historic land maps, was carried out to locate historic survey reference trees for subsequent field survey of their biophysical attributes. 81 survey trees were found in a combined study area ~5000 km2, where an estimated 1.3-2.6% of the original number remain. Tree markings ('blazes') ranged 14 - 140 years in age, where most were 120 - 130 years old, and predominately Eucalyptus species. Blaze age was strongly correlated to the thickness of bark overgrowth. Types of reference trees identified included several PM (permanent marker) trees, a cemetery marker, a trig station and 15 benchmark (BM) trees used for watercourse surveys in the mid-1800s. Eleven BM trees located were related to former irrigation surveys and were previously undocumented. Many reference trees were found in roadside vegetation or in conjunction with clumps of other large trees on farms. Being a form of living heritage, surviving survey trees possess important biodiversity and heritage values, the story of which are a useful tool for conservation and restoration activities.

biodiversity, ecosystem services, heritage

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IUFRO17-2738 **Survival of the fittest: Differentiation in livelihood resilience - Bolivian indigenous forest communities in the wake of an extreme weather event**

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Abstract: Social-ecological resilience defines the capability of a system to buffer negative effects of external shocks or disasters so as to still maintain functionality. Climate change is expected to negatively affect ecosystems and the wellbeing of poor rural households relying on ecosystems services for their livelihoods. The ability of households to withstand negative effects of climate change depends on their livelihood resilience, referred to as the capacity to sustain and improve livelihood opportunities notwithstanding environmental disturbances. Thus far, the relationship between forest dependence and livelihood resilience of rural farmers in the Amazon region is poorly understood.
A case study approach was used to identify resilience in livelihood strategies, and the role that forest products play in livelihood resilience. The sample consists of 50 households of indigenous communities from the TCO (Indigenous territory) Tacana in the Bolivian Amazon. Data was collected before and after a major flooding event in 2013 and 2015. The results illustrate how differentiated livelihood strategies increase livelihood resilience and, hence, the consequences for the social-ecological system that was affected by the extreme weather event. The study discusses under which conditions high forest dependence is a potential poverty trap or a coping strategy, capable of reinforcing household's resilience.

resilience, forest dependence, livelihood, flood

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IUFRO17-1521 **Landscape history, values of nature and their importance for forest conservation and management in the context of a discussion about The Bialowieza Forest, Poland**

Bozetka, B.* (1)

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Abstract: The study concentrates on the process of valuation of the Bialowieza Forest in Poland and engagement of landscape history (and its interpretations) in a current dispute over the ways of management of this ancient forest and, in general, over the future of the area. Particularly, it is focused on public perception of natural values and connected narratives of landscape history. The author investigates the issue of significance of naturalness and heritage for bodies involved in the discussion and decision-making processes.
A complex method of research has been employed. Apart from an insight into the evolution of landscape and forest history, it involved comparative studies, an analysis of scientific reports and policy documents, particularly forest management plans and strategies, investigation into public discussion, and an analysis of relevant media reports.
It is demonstrated that different attitudes towards the need to protect natural values of the Forest exist. Two main opposing views can be distinguished. Moreover, it is revealed that inherent values of nature and landscape authenticity have been frequently questioned by different groups. Additionally, the landscape history narrative has been used to justify an increasing pressure on ecosystems. The research stresses that constructing or re-constructing Nature not only inflicts the use of physical terms and methods, but is grounded in a value system and can be manipulated.

natural forest, landscape, protection, Poland

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IUFRO17-1502 **After the epidemic: Analyzing the policy and governance non-response to landscape-level mountain pine beetle outbreaks in the U.S. West**

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Abstract: The first decade of the twenty-first century brought with it a Mountain Pine Beetle (*Dendroctonus ponderosae*) epidemic of historically unprecedented scale in the northern Rocky Mountains of the United States. The epidemic was triggered by a combination of climate change and forest conditions favorable to beetle spread, and ultimately led to widespread pine mortality across millions of hectares of high-elevation forests as well as regional economic impacts. Despite the scale, scope, and public visibility of the outbreak, it catalyzed relatively little lasting change to forest policy or governance approaches in affected areas. In this presentation we analyze data from three case studies of national forests and surrounding communities that were heavily affected by the beetle. These case studies highlight the ways in which institutions associated with federal forest agencies--as well as the broader social and political contexts within which these institutions operate--sharply constrain the opportunities for policy adaptation and learning in the wake of social and environmental "shocks." These findings illuminate both the current state of agency-society relationships within the U.S. Forest Service and the limitations to adaptation posed by prevailing institutions. They also point to challenges to organizational and institutional adaptation to climate change-driven forest dynamics more generally.

Bark beetle, institutions, adaptation

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IUFRO17-3671 **Framings of drought risks and policy options in the forest sector: a case study from Southern Germany.**

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Abstract: Droughts are expected to become more frequent in many parts of the world in the future, including in South Germany. Whereas droughts and water shortage are recognized as substantial problems by EU institutions and many countries in South and Central Europe, there is a lack of political awareness in Germany. Droughts as a natural hazard were largely ignored both in policies as well as in legal and social science research.
Droughts affect different sectors, among them the forest sector. In the face of climate change drought management will become a future challenge to forestry in order to develop and implement management actions to increase resiliency and adaptation.
Addressing to these research gaps and policy challenges, the article investigates how droughts as natural hazards are discussed and framed in the forest sector in Southern Germany. Using methods of qualitative and quantitative content analysis, it analyses how drought risks have been problematized and politicized by the forest sector since the 1950s. It will compare problem and solution frames over time of different forest actors. The paper also discusses which policy options were chosen for coping with droughts in the forest sector. In a final step the paper identifies the need for further integration of drought management and policies within the forest sector as well as between other drought affected sectors.

drought,climate hazard,forest policy,framing

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IUFRO17-1991 **Bridging Gaps in Fire Management and Dry Forest Restoration**

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Abstract: Historical fire and forest management practices in frequent-fire forests of the western United States have contributed to forest conditions that are now generally more vulnerable to drought, insects, and wildfire. The cumulative effects of fire exclusion in particular have been pinpointed as a driving factor of increased hazard and risk with downstream feedbacks that can degrade landscape conditions and narrow opportunities for proactive risk mitigation. Forest restoration is a top priority on many landscapes of the western United States with emphasis on greater integration of fire and forest management, particularly through the reintroduction of fire. However, it is becoming apparent that myriad institutional barriers are impeding significant progress. In this presentation we will examine institutional factors affecting the decision environments of forest restoration and fire incident response and explore several types of barriers. Some of these relate to organizational structures that perpetuate single-resource management approaches, limit capacity, fail to encourage strategic thinking, and leave in place problematic incentives. Other barriers are issues of scale, including scales of planning, science delivery, and differential temporal scales of decision-making for land management. To conclude we will identify opportunities to accelerate institutional change to support more adaptive and anticipatory approaches to restoration.

natural hazards, institutional barriers, change

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IUFRO17-1058 **The end of happy days: how Irish forest stakeholders are moving from risk denial to climatic adaptive strategies**

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Abstract: In Ireland the political consensus to expand forest cover has not been really questioned for the last five decades, neither by policy-makers nor by forest owners' representatives. But in the last five years, Irish private forest owners have experienced for the first time in their life several major severe catastrophes: the outbreak of Phytophtora on larch in 2010, the arrival of Chalara on ash in 2012, and a catastrophic windstorm on Sitka plantations in 2014. All these events have shaken their convictions and beliefs about the real benefits of afforestation. For forest policy makers, framing discourses and defining strategies about risk management is now a priority in order to reassure forest owners, to incentivize them to plant again and in the same time to warn them about future risks related to forestry. Our paper aims at exploring how policy makers and forest owners are managing these multiple risks and what strategies they favour. Firstly we will see how recent climate related events have amazed forest owners and stakeholders. Secondly we will see that structural factors (wood markets, insurance costs) and individual beliefs (mistrust in institutional discourses, routines) have hampered the implementation of adaptive strategies. Thirdly we will analyse how economic incentives (reconstitution scheme), legal instruments (ban on planting some tree species) and communications tools have contributed to assist forest owners in their decision-making, in particular to reconstitute the forest after the storm Darwin. Finally we will see that Irish forest stakeholders are now gradually moving from risk undervaluing to risk integration and management.

forest owners, adaptive strategy, governance

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IUFRO17-3313 **Climate Change Adaptation Planning: Barrier to Buffering Climate Change Impacts in Nepal**

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Abstract: The relationship of climate change impacts and simultaneous human activities are vibrant in mountainous countries like Nepal which are eventually observed as the ecosystem changes significantly. This paper examines the barriers to adaptation planning approaches against climate change impacts as a regional case study in Nepal. The method includes participatory qualitative tools such as focus group discussion, key informant interview, stakeholder consultation, and direct observation including literature review. The analysis reveal that there are barriers in local adaptation planning framework and practices such as understanding the concept of ecosystem services and ability of ecosystems to adapt to significant environment changes and its socio-economic valuation and benefits to human communities as a whole. In social aspects, institutional arrangement, public awareness and participation, inadequate consultation with communities and local government, absence of the elected representatives, unclear role of community forest user groups and local government bodies are considered the major barriers to develop the climate change adaptation plan with the importance of sustainable ecosystem services and adaptation measures. In local adaptation planning, local government bodies should identify the vulnerability of key ecosystem services to climate change, possible climate-related disasters and local adaptation innovations to respond to climate change impacts and promote agro-biodiversity conservation. For doing this, regional information about climate change scenarios, down-scaling of global climate models against the climate change impacts are to be considered. The political commitment and clear and coherent operational guidelines for ecosystem managements at regional and local-levels are highly required in order to identify and address the climate change outcomes among different societal choices.

Barriers, Climate change, Planning, Impacts, Nepal

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IUFRO17-2208 **Adaptation to climate change? Why business-as-usual remains the logical choice in Swedish forestry**

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Abstract: The two latest IPCC reports concluded that knowledge is not sufficient for inducing action on climate change. This study problematizes this issue of business-as-usual through a study of the forestry sector in Sweden, which is both a large economic sector and could given the long time horizon of newly planted forest stands be expected to be an early adapter. There could thus be seen to exist both resources, economic motivation in the longer term, and environmental foundations for action. Using the Foucauldian conceptualisation of governmentality to explain the particular institutional logics that nevertheless lead to business-as-usual arguments dominating discussion on adaptation in the case of Swedish forestry, the study emphasises that adaptation must be seen as steered and limited by existing institutional, social system, logics rather than by broader, "rational" or externally defined motivations. Efforts on adaptation to climate change must thus be considered in relation to, and seek to change, existing motivational and incentive structures, and thus be conceived of through social rather than environmental logics. In fact, social logics may even define what types of actions that may at all be conceived of as adaptations.

Policy, Forest management, Governmentality

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IUFRO17-1149 **Where are the Missing Co-Authors: Principles and Practices of Co-authorship in Participatory Transdisciplinary Research Journal Articles**

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Abstract: Originally marginal, participatory transdisciplinary research has become an increasingly important methodology in the social, biophysical and interdisciplinary sciences. The overall increase in publications based on participatory research has raised questions about crediting the contributions of non-academic collaborators. Using qualitative and quantitative methods, we analyzed trends and patterns in authorship and acknowledgment practices in a sample of 262 journal articles reporting on participatory research on rural livelihoods published from 1975-2013. Six percent of the researchers recognized the intellectual contributions of their non-academic collaborators with co-authorship and 51 percent with acknowledgment. Through interviews with lead authors of co-authored articles, we analyzed factors that shaped whether authorship was shared with non-academic collaborators. Despite facing numerous barriers, researchers were motivated to co-author in order to recognize intellectual contributions, practice research ethics and work towards epistemic decolonization. We outline the work of authorship in scholarly publications and argue that co-authorship can be an important component of epistemic justice in participatory transdisciplinary research and encourage participatory transdisciplinary researchers to discuss authorship with their non-academic collaborators as a routine component of participatory transdisciplinary scholarship. We also note that non-academics' contributions to scientific knowledge needs to be taken into account in understandings of the practice of science.

co-authorship, participatory, epistemic justice

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IUFRO17-1263 **Different ways of being transdisciplinary: forest research in the real-world laboratory "Knowledge Dialogue Northern Black Forest", Germany**

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Abstract: Real-world laboratories aim at bridging the gap between daily-life problems and scientific knowledge production by bringing together scientists and actors from outside academia in transdisciplinary settings during the whole research process. However, transdisciplinarity does not come without challenges since science and praxis still follow distinct internal logics. Thus, when working within transdisciplinary research projects, scientists are faced with expectations that deviate from the demands into which they have been socialized during their scientific education and career. Consequently, it has to be expected that scientists engaged in real-world laboratories are faced with a balancing act between inner-scientific demands and the requirements of participatory forms of research. In this presentation, we reflect on the challenges researchers are facing in the real-world laboratory "Knowledge Dialogue Northern Black Forest", in which an interdisciplinary group of more than 20 researchers together with stakeholders analyse and evaluate the ecological, social and economic interrelations between the newly founded National Park and the surrounding region. In theoretical terms, the presentation builds on concepts from the fields of sustainability science and science and technology studies. In methodological terms, it draws on interviews with the involved scientists, participatory observations but also critical reflections by the authors themselves.

research process; participation; National Park

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IUFRO17-2282 **Transdisciplinarity in International Forestry Research: An Assessment of Four CIFOR Projects**

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(1) Center for International Forestry Research, Bogor Barat, Indonesia; (2) Royal Roads University, Victoria, Canada

Abstract: As boundaries between disciplines are crossed, and as research engages more with stakeholders in complex systems, traditional academic definitions and criteria of research quality are no longer sufficient; there is a need for a parallel evolution of principles and criteria to define and evaluate research quality in a transdisciplinary research (TDR) context. We used a systematic review of the literature on TDR quality to develop a prototype TDR quality assessment framework (QAF), which we tested empirically in four international forestry research projects conducted by the Center for International Forestry Research. The data were collected using participatory evaluation workshops, semi-structured stakeholder interviews, and document analysis. The developed TDR quality assessment criteria of the framework helped to evaluate the degree to which current projects are employing transdisciplinary approaches and to systematically evaluate strengths and weaknesses in the projects reviewed. We found good examples of the application of transdisciplinary principles and criteria but also considerable scope to further improving research design and implementation for improved effectiveness. This presentation will provide an overview of the QAF and the assessment methods, results and lessons learned for designing and evaluating TDR in the forestry sector.

Transdisciplinary; Research Quality; Engagement

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IUFRO17-3856 **Solving problems in forest landscapes as social-ecological systems: barriers of transdisciplinary research**

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Abstract: Translating policies aiming at sustainable forest landscapes as a societal process and sustainability outcomes on the ground involves multiple challenges. Hence, improved innovative problem-solving capacity is needed. One solution is transdisciplinary research that integrates research disciplines as well as researchers and practitioners. First, drawing upon a sample of experiences of problem-solving we used group modeling to map perceived barriers and bridges for researchers' and practitioners' joint knowledge production and learning towards transdisciplinary research. The analysis indicated that the transdisciplinary research process is influenced by the amount of traditional disciplinary formal and informal control, integration of project applications to fill the transdisciplinary research agenda, researcher and stakeholder engagement, and team integration of them based on self-reflection and experienced leadership. Second, we present a transdisciplinary place-based research approach in seven steps that includes both diagnosis and treatment of landscapes as social-ecological systems. This was applied during the five years to co-produce knowledge through integration of research and practitioners concerning implementation of green infrastructure policy in forest landscapes in the Baltic Sea Region. Finally, we discuss a role of different landscape approach initiatives (Model Forest, Biosphere Reserve) in practicing transdisciplinary research.

place-base research, group modelling

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IUFRO17-4029 **Generating better knowledge through cooperation with policy actors? Reflecting on experiences made in a "transdisciplinary" policy implementation research project**

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Abstract: The analysis of forest and environmental policy is per se facing a certain dilemma. On one hand, close access to the policy making process, understanding of the issues at stake, and also mutually trustful relationships to policy actors who are the central source of information are the preconditions for empirically oriented policy analysis. On the other hand, exactly such relationships to policy makers can also be seen as a major obstacle for critical assessments. This is as the latter inevitably requires the necessity to abstract from specific political positioning and interests in order to interpret and present them. This situation creates a continuous challenge not only for scientists and researchers, but also for policy makers engaging in knowledge exchange at the science-policy interface.
In this presentation, we reflect on experiences made in an interdisciplinary research project which was, in its social science part, meant to empirically analyze the "street level" implementation of nature conservation objectives and measures through forest rangers in Germany. Given the political nature of the issue and the necessity of close field access to generate meaningful knowledge, a transdisciplinary research design was chosen that involved the respective forest policy actors from the beginning on. While, on one hand, negotiated compromises had to be made in the design and practice of the research process, on the other hand, repeated close and frank interaction created increasing mutual understanding and trust between the political actors and scientists, and, moreover, positively impacted research questions, the methodology and interpretation of the data. We conclude by formulating some working theses for transdisciplinary policy research against the background of these experiences.

policy analysis,co-design,science-policy-interface

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IUFRO17-589 **Economic valuation of the forest of life and death by direct and indirect beneficiaries for the recovery of the biocultural landscape**

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Abstract: Due to the inadequate management and the gradual fragmentation of the carob relict of the Tiataco community. An economic valuation work was implemented by the direct and indirect beneficiaries as an alternative to recover the biocultural landscape for Vivir Bien, a new paradigm of the Plurinational State of Bolivia.

In the community of Tiataco, jurisdiction of the municipality of Arbieto, 3rd Section of the province Esteban Arce, Cochabamba, Bolivia, there is a relict of 12 hectares of centenarian carob trees that for many years was only making a landscape presence, without the community and its inhabitants Can take advantage of the diversity of environmental services provided by the forest. In order to demonstrate the integral potential of the forest, several theoretical and practical activities (eg forest inventory) were developed together with the community members to identify the socio-economic and cultural value of the forest.

The economic valuation of the relict allowed the comparison between direct beneficiaries (families resident in the community) and indirect (families living in the city of Cochabamba, 35 km from Tiataco) applying the methodology of contingent valuation with binary format.

As a result, the willingness to pay by the direct beneficiaries was 58.42 Bs / year (8.39 USD / year) and 105.288 Bs / year (15.12 USD / year) for the indirect ones (exchange rates April 2016 BCB: 1 $ US = 6.96 Bs).

Based on this exercise of economic valuation of the relict, it is hoped to implement actions of conservation and silvicultural management, as well as the recovery of biocultural knowledges that promote and dynamically balance relationships and harmony between man and nature, together with the creation of models Of local economic development.

economic valuation biocultural heritage

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IUFRO17-714 **Transforming nomadic traditions to biodiversity-friendly livelihoods from the perspective of traditional forest-related knowledge: the successful story of H Village of Yunnan Province in China**

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Abstract: Can we achieve the dual goals of biodiversity conservation and improved lives for indigenous communities? H village of Yunnan province is one of the successful cases. This paper took this case as an example and examined it to understand how its success happened from the perspective of traditional forest-related knowledge. The study documented periodic land and forest tenure reform from 1950 to present and major development interventions by the Chinese government and foreign donors. The culture and religion of the Lisu people, and the ways Lisu people have lived with natural resources and village regulations, were invented through long-term practical experience living with nature and inherited generations by generations. With modern technologies and culture, the traditional forest-related knowledge and culture have faced great challenges. In their livelihoods recently, the Lisu People have reduced dependence on forest products. "Slash-and-burn" farming and nomadic lifestyles have been transformed to agroforestry practices for commercial crops and off-farm jobs. The case of H village proves that, with proper interventions, humans can achieve dual goals to improve the livelihoods of local residents and preserve biodiversity in the era of modernisation, globalisation and marketisation. The story of H village tells us that the relationship between humans and nature should be interactive and interdependent, and thus biodiversity conservation should be based on the socio-ecological system as a whole, not separating humans from natural ecosystems. We should fully consider traditional forest-related knowledge (TFRK) as an asset of local minorities and activate it in this era of globalisation, marketisation and privatisation towards sustainable development.

Lisu; cultural change; forest polices

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IUFRO17-4116 **Reconstruction of forest fire scenarios in the inner regions of the Iberian Peninsula through the geo-historical sources, 18th-20th centuries**

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Abstract: The evolution of the fire and forest landscape has not been linear neither in space nor in time. For centuries, fire had been present as a common practice in land management and this rural culture of fire meant a frequent but controlled use of it, limiting its catastrophic manifestations. In historical periods of crisis situations and territorial instability, it is known that the frequency of fires and its resulting affected area increase. Both the fire regime and territorial dynamics have changed much throughout history, which explains the configuration of different risk situations and forest fire scenarios. Fire scenarios are defined as areas of homogenous fire ignition and fire spread patterns.
The existing wildland fires statistics cover a very short period of time. In Spain, the Estad ística General de Incendios Forestales (EGIF) starts in 1968, and in Portugal the Rural Fire Database begins in the year of 1980. However, the geo-historical sources do allow to complete previous data, making it possible to learn about the evolution of fire regimes. In the Complutense University of Madrid it is being prepared the first Historical Record of Wildland Fires (RHIF) in Europe. This database has about 7,000 records of pre-statistical fires (starting in 1492)obtained through geo-historical sources.
Based on the knowledge of territorial scenarios of current fire and the database of historical fires, the main objective of this research is to understand how the fire scenarios were shaped. The scale is local and dynamic, taking as reference three historical moments with territorial geo-referenceable data or mapped data: the late nineteenth century (Planimetry of the late s XIX 1874-1908), mid-twentieth century (aerial photograph 1957) and 2000 (Corine Land Cover). The research is developed in selected case studies, with a perimeter of about 10,000 hectares.
This research is contributing to integrated fire management and fire risk governance in the context of global change.

Forest fires, Pyrogeograpy, landscape dynamics

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IUFRO17-403 **A Study on the Retention of Forest-related Traditional Knowledge - A Case of Dengcen village in Guizhou Province, Southwest China**

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Abstract: Local communities have relied on traditional knowledge (TK) to manage forests and utilize forest resources for centuries, and the TK helped them keep the capacity of forest ecosystems in providing environmental services. Such forest-related traditional knowledge (FTK) including local peoples' ecological knowledge, culture, belief and forest management know-how has been transmitted through generations. Nevertheless, industrialization and scientific development has eroded FTK and its retention is now facing challenges. This study aims to understand the status of FTK retention, and further identify socio-economic factors that have affected the retention. For these purposes, the vitality index of FTK retained by a local community called Dengcen - which is located in Guizhou province in Southwest China - was measured by utilizing Vitality Index of Traditional Environmental Knowledge (VITEK) method. We suggest, to help the FTK to be maintained, FTK training program for young local people and culture-based ecotourism with active involvement of local community should be developed as well.

traditional knowledge, local community, retention

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IUFRO17-2194 **Selective and cumulative rewilding**

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Abstract: Protected landscapes as IUCN category V. are designed to "link nature, culture and community". Their management should thus to a greater degree protect also traditional land uses and biodiversity connected to these. In the presentation the dedication to this bio-cultural approach will be put to a test in a specific case study.
On a chosen area in W Bohemia, the protected landscape management's bias for the "hands-off" approach or the "strict reserve concept" will be shown as opposed to more biocultural diversity related approaches. Also the paradox of this approach will be pointed at - that the parts of new nature are selected and the natural processes orchestrated to eliminate traditional management elements.
The aforementioned principle will be shown on the fate of forests, wooded meadows and pastures. The case area - Tachov region, is a typical example periphery characterized by remoteness from the centers and lower socio-economic potential. It is a border region near Czech-Bavarian borderline, former "Sudetenland". Part of the region is from 2005 listed under Czech protected landscapes (CHKO Cesk ý les), majority is unprotected. The landscape development was similar in both the protected and unprotected area till approximately 1990s. Till 1945 we could find here a mosaic of fields, pastures and forests, than, after the Czech Germans eviction and during the cold war, the agriculture or forestry here either intensified or ceased at all.
After 1990s many of the wooded areas including pastures and meadows in the unprotected zone of Tachovsko region were subjected to the natural succession, or as we can say, cumulative rewilding, leading to creation of unappreciated and unnoticed areas of wilderness of specific kind. In protected landscape, the same however was not allowed to happen as these were selectively cut out. On the same note selected parts of forest started to be strictly managed in order to transform them into "primeval forests".

rewilding, selection of ecosystems, Bohemia

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17 - Integrating grassroots participation, crowd mobilization and big data analysis in forest restoration

KG I - Aula (Uni Freiburg)

IUFRO17-3755 **Towards an integrated assessment for landscape approach: combining remote sensing, crowdsourcing big data and multi-objective modelling**

Yowargana, P.* (1); Kraxner, F. (1); See, L. (1); Fuss, S. (2); Dewi, S. (3); Mosnier, A. (1); Ramos, F. (4); Câmara, G. (4); Samadhi, N. (5); Warta, Z. (6); Chatterton, P. (7)

(1) International Institute for Applied Systems Analysis, Laxenburg, Austria; (2) Mercator Research Institute (MCC), Berlin, Germany; (3) World Agroforestry Centre (ICRAF), Bogor, Indonesia; (4) National Institute for Space Research (INPE), São José dos Campos, Brazil; (5) World Resources Institute (WRI) Indonesia, Jakarta, Indonesia; (6) WWF Indonesia, Jakarta, Indonesia; (7) WWF, Vienna, Austria

Abstract: Complex interaction of ecosystem services, biodiversity, and socio-economic activities calls for a landscape approach to complement large scale conservation efforts. Such an approach requires comprehensive and integrated addressing of multiple objectives in areas where pressure for high-monetary value activities are in direct competition with environmental benefits and biodiversity resources. There have been numerous field implementations that combine many activities (e.g. restoration, sustainable agriculture, conservation, eco-tourism and rural clean energy provision) in a particular landscape. These projects often involve lengthy participatory deliberation that have been proven effective in generating sustaining results.

Challenge arises in the effort of rapid upscaling of landscape approaches. Low-cost assessment and monitoring mechanisms are required especially when large scale mobilization of funds are involved. For such purpose, complex interaction and inclusive processes in landscape approaches make it challenging to formulate assessment mechanisms that allow robust yet operational evaluation of projects. In the RESTORE+ project remote sensing is combined with citizen science to obtain information on biophysical and social complexity of degraded/marginal land. The information is then fed into multi-objective models that assess restoration and utilization options. Such combination is capable of linking qualitative information with socio-economic and environmental parameters to assess landscape approaches in a comprehensive yet efficient way.

landscape;land-use model;restoration;crowdsourcing

KG I - Aula (Uni Freiburg)

IUFRO17-2008 **Harnessing the power of volunteers to collect and validate spatial information using Geo-Wiki: Relevance to forestry**

Schepaschenko, D.* (1); Fritz, S. (1); See, L. (1); Perger, C. (1); Dürauer, M. (1); Sturn, T. (1); Lesiv, M. (1); McCallum, I. (1); Laso Bayas, J. C. (1); Karner, M. (1); Kraxner, F. (1)

(1) International Institute for Applied Systems Analysis, Laxenburg, Austria

Abstract: Citizen science and crowdsourcing applications have been growing in number during the last decade. The reasons for this include recent advances in technology and the willingness of citizens to participate in scientific research to help solve a range of environmental problems. The advances in technology include open access to very high and high resolution imagery (e.g. as presented in Google Earth or Bing Maps); GPS-enabled mobile devices, which allow geo-referenced photographs to be taken and access to different sensors (e.g. gyroscopes); and fast internet connections. Some of the new, emergent applications are also relevant to forestry, e.g. they allow one to: 1) gather information for monitoring disturbances (e.g. wildfire, shifting cultivation, and harvesting); 2) measure forest parameters (e.g. relative stocking and tree height) with mobile devices; and 3) validate land/forest cover maps. IIASA, in particular, has developed several relevant applications including the Geo-wiki.org portal with a branch devoted to forest, mobile applications (e.g. Geo-Wiki Pictures, FotoQuestGo) and serious games such as Picture Pile and Picture Paint. Through regular crowdsourcing competitions run at IIASA, we encourage people to participate in a range of validation campaigns. Incentives include prizes and co-authorship on publications arising from the analysis or application of the data collected. Examples of research using the collected data includes the independent validation of existing land cover, forest, human impact maps; and the production of hybrid maps with known uncertainty. Independent validation has shown that the hybrid products have better accuracy then any of the initial input datasets. These hybrid products include up-do-date and validated forest cover, which reflects the effects of climate change, disturbances and management practices.

crowdsourcing, forest cover, remote sensing

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IUFRO17-3352 **Toward a successful forest and landscape restoration in Sumatra, Indonesia: the application of Restoration Opportunities Assessment Methodology**

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(1) World Resources Institute Indonesia, Jakarta Selatan, Indonesia; (2) World Agroforestry Center (ICRAF), Bogor, Indonesia

Abstract: Restoring degraded lands and landscapes is essential for human livelihoods and well-being, long-term food security, biodiversity conservation, water regulation, and climate stability. Given the complex use and function of lands and landscapes, restoration is multifaceted and involves various stakeholders and strategies. To assist restoration stakeholders in assessing national and subnational restoration potential systematically and comprehensively, the World Resources Institute (WRI) and the International Union for the Conservation of Nature (IUCN) developed a framework named Restoration Opportunities Assessment Methodology (ROAM).

The World Agroforestry Center (ICRAF) and WRI Indonesia have been testing and implementing ROAM within the Musi and Batanghari watersheds in Sumatra to strengthen regional capacity in the planning of forest and landscape restoration. The implementation of ROAM results in the identification of restoration intervention options, priority areas for restoration, cost and benefit calculation for each type of intervention, diagnosis of the presence of key success factors, strategies to overcome major obstacles for restoration, as well as financial analysis and financing options for restoration. Our ROAM analyses suggest that there is strong feedback between restoration planning at the macro-level (provincial or watershed), meso-scale (district), and micro-scale (forest management unit). Synchronization of restoration planning at all three levels is important so that restoration incentives can be effectively leveraged and past failures of restoration projects will not be repeated. Further, our participatory ROAM framework could provide the backbone for an effective restoration monitoring system, including through crowdsourcing.

restoration; Sumatra; Indonesia; planning

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IUFRO17-1511 **Effect of Harvesting Practice on Forest Stand Condition: A case from Terai Community Forest of Nepal**

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Abstract: Community forest management plans in Nepal are generally prepared to support sustainable harvesting of forest products in relation to the management objectives and the needs of the user households. However, users either rely on traditional knowledge or on schematic instructions by the government officials, which can result in an inadequate utilization of forest resources. This paper analyzes the harvesting practice of forest products, especially timber in the community forest in the Terai region and its effect on forest stand conditions using the forest inventories panel dataset of four consecutive periods (2005, 2010, 2013 and 2016). Users, executive members and forest officials were consulted on harvesting practices together with a content analysis of the plan and harvesting records. The result reveals that users were harvesting close to 50 percent of the prescribed annual cut laid down in the plan. This under utilization of the forest resources is the result of the combined effect of conservative motives of the users and the greater enforcement of arbitrary harvesting rules. Furthermore, users were practicing selective felling, where poor quality trees were removed. On the other hand, cutting of saplings and seedlings for grasses is quite common. As a result, the number of tree per hectare has increased from 437 in 2005 to 642 in 2016 while that of sapling decreased from 440 to 141during the same period. In addition, the low light penetration inside the forests due to improper spacing and crown thinning had negatively influenced the development of natural regeneration. Results indicate that the current harvesting practices has improved the tree stand condition, while the inverse pyramid of forest stands structure well-informed the possibility of degradation of forest in the future. We suggest the need to scrutinize the appropriate forest management and harvesting practices in community forest for ensuring its sustainability.

Harvesting, Inventory, Forest condition, Nepal

KG I - Aula (Uni Freiburg)

IUFRO17-3645 **Forest Restoration Strategies in Brazil within the Scope of the New Forest Code**

Soterroni, A.* (1); Ramos, F. (2); Mosnier, A. (1); Carvalho, A. (3); Camara, G. (2); Obersteiner, M. (1); Pirker, J. (1); Andrade, P. (2); Kraxner, F. (1); Havlik, P. (1); Maus, V. (1); Scarabello, M. (2); Pena, M. (3)

(1) International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria; (2) National Institute for Space Research (INPE), Sao Jose dos Campos, Brazil; (3) Institute for Applied Economic Research (IPEA), Brasilia, Brazil

Abstract: After a long debate in the Parliament, a revision to Brazil's Forest Code (FC), which dates from 1965, was approved in 2012. The FC regulates land use and environmental management on private properties, and, among its main provisions, requires that illegally deforested areas be restored at the landowners' expense. Here we explore different scenarios of forest restoration and evaluate trade-offs associated with the implementation of the new FC. To this end, we spatially project Brazil's land-use change and agricultural outputs through 2050, taking into account external trade and exogenous drivers such as gross domestic product (GDP) growth, population growth, and dietary trends. Our approach is based on a bottom-up global economic partial equilibrium model of agriculture, forestry and bioenergy sectors. The overall goal of this study is to identify specific areas for forest restoration and sustainable use, as well as the implications of different restoration strategies on land-use change, production and GHG emissions. Results are expected to support Brazil's contribution to meeting the "Bonn Challenge".

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179 - Forest policy and governance: research at multiple scales

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1894 **Overall assessment of FLEGT and EUTR state of the art from the stakeholders' perspective**

Portaccio, A.* (1); Pettenella, D. M. (1); Masiero, M. (1); Andrighetto, N. (1); Muys, B. (2); Verbist, B. (2)

(1) University of Padova, Department of Land, Environment, Agriculture and Forestry, Legnaro, Padova, Italy; (2) KU Leuven - University of Leuven, Department of Earth and Environmental Sciences, Heverlee, Belgium

Abstract: FLEGT and EUTR are EU legal instruments to halt illegal logging, a major issue in economic, social, environmental and political terms. Different and contrasting convictions about their effectiveness blossomed over time. Our study surveys the overall stakeholders' perspective, offering a 360° view of FLEGT and EUTR state of the art. The methodology consists in a double stage literature review and a set of interviews with several actors, distinguished according to their main sector of activity (academics and experts; business and trade actors; civil society and environmental organizations; political and technical actors). They expressed their opinions about FLEGT and EUTR strengths, weaknesses, opportunities and threats regarding the following topics: policies, legal framework and governance; business and trade; stakeholders and social issues; environmental sustainability and deforestation; and the possible interactions with other initiatives. Unanimous appreciation emerged about the innovative character of the initiatives and the success in awareness raising and social inclusion. Most criticized a missing centralized orchestration by the EC; while opinions diverged on the acknowledgement of certification schemes and private sector involvement. Environmental impacts were slightly commented. In the end, research outcomes are compared with those emerged from evaluations commissioned by the EC and some recommendations to policy makers are offered.

FLEGT,EUTR,illegal logging,stakeholders,policies

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2394 **Money for Signatures or Signatures for Money? Using Public Choice to Study Forest Policy**

Zhang, D.* (1)

(1) Auburn University, Auburn, United States

Abstract: In this paper, we first illustrate how public choice has been used to study forest policy. We then present a study on whether interest groups use campaign contributions to influence legislative voting behavior in terms of bill cosponsorship. In particular, we look into the signature on the TREE (Timber Revitalization and Economic Enhancement) Act of 2007, which is the only major forestry act in the 2007-2008 Congress. We find evidence that suggests interest groups are using campaign contribution to influence bill cosponsorship as well as election results. Further, forestry interest groups do pay key committee (the Ways and Means Committee) members up front.

Interest group theory, campaign contribution

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-2910 **Adaptive governance, weaving Maori aspirations and livelihoods into policy and implementation, a systems approach to forest-based regeneration.**

Barnard, T.* (1); Porou, T. (2); Wreford, A. (3); Edwards, P. (4)

(1) Scion, Rotorua, New Zealand; (2) Poipoia Limited, Turangi, New Zealand; (3) Scion, Christchurch, New Zealand; (4) Scion, Wellington, New Zealand

Abstract: This paper will discuss the role of adaptive approaches to governance in delivering social, economic, cultural and environmental outcomes for a large Maori community in New Zealand. Inter-agency partnership, a systems-based understanding of roles and functions and an innovative game-based approach to the co-development of solutions with end-users are required if the aspirations of the tribe are to be met.

We will describe how a legacy of shocks and events have adversely affected the catchment and its people. Extreme levels of erosion, rural decline, outward migration and lack of economic opportunity have combined to threaten the cultural sustainability of the tribal community of Ngati Porou.

The New Zealand Government has formally committed to a 100-year partnership with the tribe to restore the Catchment under a Memorandum of Understanding signed in 2014. This agreement, with the aspirational aim of 'healthy land, healthy rivers, healthy people', provides a backdrop to our research into livelihoods, social networks, policy contexts and enabling environments. Using adaptive governance approaches we will explain how forest-based transformational change is being explored in one of the most challenging and culturally significant environments in New Zealand.

Adaptive governance, system analysis, livelihoods.

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Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1097 **Transformational change through REDD readiness in Nepal: realities amidst expectations**

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(1) District Forest Office Syanja, Department of Forests, Putali Bazaar, Nepal

Abstract: The national REDD+ program in Nepal was initiated in 2008 by the Ministry of Forests and Soil Conservation, under the grant support of FCPF/World Bank. The readiness phase, which marks the first phase in the mechanism, has established an institutional set up for REDD governance and prepared policy documents including a draft REDD strategy. Only recently, the country has obtained additional funding for readiness. Preparations for a sub-national project are underway, with the country in pipeline for the carbon fund of the World Bank. In light of these developments, this research sought to comprehend how the readiness process is interacting with and influencing the broader forestry governance in the country. The results support a better understanding of how likely the transformational ambitions of REDD+ are in the context of Nepal, and point to necessary changes to the approach undertaken thus far.
The study is based on a documentary analysis and qualitative interviews with experts working with REDD+ in the country. The findings indicate that the readiness process has not been not able to reach its objectives due to the persistence of ineffective governance in the forestry sector, which has largely affected the REDD+ policy-making process. Problematic governance issues include path dependencies and the 'stickiness' of the bureaucratic institutions, along with a lack of political commitment. In the light of the lack of cohesion within the pubic authorities involved in the process, donors have turned to NGOs bestowing them with considerable resources. Moreover, the donor-driven readiness mechanism with 'tailored' readiness activities has affected the empowerment of government institutions through the heavy reliance on experts and consultants. The research argues that unless donors and policy makers work to reform the forestry sector governance in Nepal, transformational change through REDD+ will be an immensely challenging task.

REDD+, readiness, institutions, donors, governance

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3300 **Governance capacity of public actors in forestry: An analytical framework for facilitating social innovation**

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(1) University of Padova, Department of Land, Environment, Agriculture and Forestry, Legnaro (PD), Italy; (2) University of Freiburg, Faculty of Environmental and Natural Resources, Freiburg, Germany

Abstract: The shift "from government to governance" should have brought a decline of command-and-control regulations and a redistribution of power and responsibilities. In most European countries, these reforms included public policies and sectors. Nevertheless, it seems that the forest sector is still hierarchically organized, with predominantly public actors, where decision-making is top-down. To what extent, do these structures constrain the forest sector's social innovation? The European Commission views social innovation as a means to address complex societal problems. But to day, social innovation in the public sector has received less attention, perhaps thinking that institutional inertia was incompatible with innovation. Today, however, the question is how should the public sector foster innovation, not if. The aim of this paper is to explore the governance capacity of public forest sector for social innovation in the European context, which we understand as the ability of actors to work together in solving common problems in forestry. To fulfill this aim, we conducted a rigorous and extensive review of the literature on social innovation, focused specifically on governance capacity in natural resource management. Several elements of governance and social innovation emerged and created our framework for analyzing governance capacity, especially of public actors in the forest sector at national and local levels. Preliminary results indicate that for social innovation in forestry, governance capacity is found in the relationships among the state-private sectors, the state-civil society actors, and private sector-civil society actors. This suggests that principles of collaborative governance strengthen social innovation capacity.

governance capacity, social innovation, forests

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IUFRO17-3800 **Advanced approaches for a better understanding of scientific knowledge transfer for interconnecting forest-related policies, science and people - an introduction**

Böcher, M.* (1)

(1) Otto-von-Guericke-Universität Magdeburg, Chair of Political Science and Sustainable Development, Magdeburg, Germany

Abstract: Interconnecting forests, science and people for achieving a sustainable life on earth is often a question of how forest-related policy decisions from the global to the local level are based on latest scientific findings. Especially natural scientists often claim that politicians neglect their forest-related findings whereas political actors state that science that they need has to be well in time, practically usable and directed towards their current political problems. An irony is that, despite this central "misunderstanding" between scientists and political actors, modern forest policy that includes aspects that go much beyond traditional forestry is more and more dependent on interdisciplinary science-based expertise. For a successful interconnection between forests, science, and people, we need an advanced knowledge about the conditions under which scientific knowledge transfer can be successful to be utilized in respective forest-related policies. The contribution will take up this crucial question and serves as an introduction to Part B of session 43

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IUFRO17-160 **Applying the RIU-model of knowledge transfer in practice: Experiences from the EU-project ALTERFOR**

Jürges, N.* (1); Krott, M. (1)

(1) Georg-August-University Göttingen, Chair of Forest and Nature Conservation Policy, Göttingen, Germany

Abstract: Participatory research approaches aim at improving the knowledge transfer into practice. Participatory research projects aspire close cooperation with all stakeholders to gain support for implementation of an innovative scientific solution. But this endeavor often fails. In contrast, the RIU-model stresses the importance of autonomous high quality research and is looking for various formal and informal allies to implement different science-based concepts. This RIU model is applied to allow knowledge transfer and tested within a comparative EU-project. The EU-project ALTERFOR- "Alternative models for future forest management" examines alternative forest management concepts based on ten case studies representing different prevailing forest management practices and socio-ecological conditions in Europe. ALTERFOR applies the RIU-model of knowledge transfer in research practice.

The assumptions of the RIU-model and its practical application are empirically tested within ALTERFOR based on a triangulation of qualitative methods. It is presented how knowledge transfer based on the RIU-model has been implemented within ALTERFOR. Potentials and limitations of knowledge transfer based on the RIU-model within ALTERFOR are discussed.

RIU-model; knowledge transfer; power

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IUFRO17-2252 **How do we conduct forest-related research in ways that enhance its impact on policy and practice?**

Edwards, D.* (1)

(1) Forest Research, Social and Economic Research Group, Roslin, United Kingdom

Abstract: This presentation reports on activities and findings, at the mid-point in a four-year programme, to understand and demonstrate how to conduct applied forest-related research in ways that enhance its impact on policy and practice. Led by Forest Research (the research agency of the UK Forestry Commission), the programme asks: under what conditions can improved transdisciplinarity and knowledge exchange between researchers, intermediaries and end-users help generate: a) direct instrumental changes to policy and practice; b) conceptual changes in understanding; c) capacity-building; d) enduring connectivity; and e) changes in culture and attitudes and towards the impact agenda itself? The activities include: literature reviews to determine best practice; social network analysis and participatory methods to understand current levels of connectedness; workshops to encourage social learning; 30 short case studies exploring examples of research impact; and a single, in-depth study focusing on decisions around tree species and provenance selection over the last three decades. The programme considers a spectrum of strategies and mechanisms: dissemination, interaction, social influence, facilitation, and incentives & reinforcement. In conclusion, we highlight the value of embedding 'reflective practice' into organisational cultures and routines, to encourage learning and appraisal, and inform future actions.

knowledge exchange, transdisciplinarity, impact

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IUFRO17-2678 **An Empirical Evaluation of Knowledge Translation in Policy-Relevant Forestry Research**

Davies, B.* (1); Belcher, B. (1); Abernethy, P. (2)

(1) CIFOR, Bogor, Indonesia; (2) Royal Roads University, Victoria, Canada

Abstract: The increasing external demand from research funders and research managers to assess, evaluate and demonstrate the quality and the effectiveness of research is well known. Less discussed, but equally important, is the evolving interest and use of research evaluation to support learning and adaptive management within research programmes. Researchers and research managers need to know whether and how their work is contributing to positive social and environmental outcomes to be able to adapt and improve their projects and programmes. We have done a series of theory-based evaluations of international forestry research projects. Each evaluation began with documentation of a theory of change (ToC) that identified key actors, processes and results. Data collected through document reviews, key informant interviews and focus group discussions were analysed to test the ToCs against evidence of outcomes in the form of discourse, policy formulation and practice change. The analyses identified strengths and weaknesses in knowledge translation, helped understand the conditions and mechanisms of knowledge translation and suggested improved strategies to increase research effectiveness. The evaluation approach proved valuable as a learning tool for researchers and research managers and it has facilitated communication with funders about actual and reasonable research contributions to change.

Effective Research Evaluation; Transdisciplinary

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IUFRO17-1268 **Formation and Political Power of Forest Owners Associations in the Czech Republic and Slovakia**

Salka, J.* (1); Dobsinska, Z. (1); Sarvasova, Z. (2); Sterbova, M. (1); Jarsky, V. (3); Oliva, J. (3); Hrib, M. (3)

(1) Technical University in Zvolen, Zvolen, Slovakia; (2) National forest centre, Zvolen, Slovakia; (3) Czech University of Life Sciences, Praha, Czech Republic

Abstract: The aim of this presentation is to analyse the formation and political potential of forest owners associations (FOAs) in the Czech Republic and Slovak Republic. Firstly, the paper examines the concept of formation of interest groups and factors of their political power. Interest groups seek to be able to use their power through influencing policy outcomes and framing the underlying dimensions that define policy issues. In the next step the presentation defines factors of dispositional power: formal, informal, internal, and external.
Methodologically, at first we analysed primary and secondary documents as legislation, strategic documents, web pages of FOAs, annual reports, etc. Secondly, we identified all FOAs in the Slovak Republic and Czech Republic and their current and former officials (president or executive secretary). We used a semi-structured questionnaire containing questions focused on the formation and role of FOAs in policy making.
The crucial internal factor for both countries limiting the dispositional power of FOAs is the "free rider" problem and the lack of financial resources for providing services or necessary apparatus, which might strongly hinder the fulfilment and achievement of set goals in policy making. The disinterest of the state bureaucracy in Slovakia towards non-state forests also limits FOAs' dispositional power. Forest owners associations in the Czech Republic and Slovak Republic need to strengthen their position via lobbying, public relations, knowledge, or expertise and could use demonstrations, rallies, petitions, media statements, and participation in public debates to achieve their objectives and to strengthen their political potential.

political power, forest owners associations

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IUFRO17-1289 **Actors and effects of their power on forest management in Slovakia**

Brodrechtova, Y.* (1); Smrecek, R. (1); Bahýl, J. (1); Bosela, M. (1); Sedmák, R. (1); Tucek, J. (1)

(1) Technical University in Zvolen, Zvolen, Slovakia

Abstract: Current and developing demands for ecosystem services increasingly challenge forest management, which in turn is regulated by national systems. Analysis of the actors and networks behind or against specific forest management is crucial if an alternative to these systems is to be introduced. More precisely, according to the Research, Integration and Utilization (RIU) model assessing the roles of relevant actors and their power could help to avoid attempts to reach policy consensus but instead to focus on specific actors with specific competences. With Slovakia the subject of this study, using the actor analysis offers an opportunity to isolate the key actors and their networks, mapping their political and economic potential, respectively power in regard to forest management and ecosystem services in a cohesive way. The motivation to analyze the nexus between actors and their networks and forest management in the case of Slovakia- country from the Central and Eastern Europe (CEE) region is twofold. First, it seems interesting to check whether institutional changes, which were launched in the early 1990s have various consequences on actors and their networks. Secondly, an actor analysis has not been so far applied by many researchers focused on CEE region. Qualitative research methods such as focus group and subsequent in-person interviews with around 30 purposefully selected stakeholders and experts concerning forest management are used. The preliminary results indicate a strong involvement of both forestry and non-forestry actors outside of the traditional forestry network in Slovakia. Targeting these key actors could open the door for the adoption of alternative forest management appropriate to the desired combination of ecosystem services in the CEE country analyzed.

actor analysis, power elements, FM, Slovakia

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IUFRO17-3946 **Implementation of forest-related policies by state forest institutions from former Yugoslavian countries: state of the art and future perspectives**

Stevanov, M.* (1); Krott, M. (2); Matijasic, D. (3); Krajter Ostoic, S. (4); Curman, M. (5); Stojanovski, V. (6)

(1) Institute of Lowland Forestry and Environment, University of Novi Sad, Novi Sad, Serbia; (2) University of Goettingen, Chair of Forest and Nature Conservation Policy, Goettingen, Germany; (3) Slovenian Forest Service, Ljubljana, Slovenia; (4) Croatian Forest Research Institute, EFI SEE, Zagreb, Croatia; (5) Croatian Forest Research Institute , EFI SEE, Zagreb, Croatia; (6) Ss. Cyril and Methodius University, Faculty of Forestry, Skopje, Macedonia, the former Yugoslav Republic of

Abstract: For the former Yugoslavian republics, being independent countries today, forests were important natural resource. That remained unchanged also in the period of transition toward democracy and market economy, which started in the 1990s and brought numerous substantial changes. Governments enacted new forest laws and forest development strategies were formulated through participatory processes, among others. Restructured state forest institutions faced the challenge of guarantying implementation of respective public goals. We take examples of Serbia, Croatia, FYR Macedonia, Republic of Srpska (49% of Bosnia and Herzegovina territory) and Slovenia: (i) to illustrate developments in forest-related policies so as (ii) to show which priority goals from these policies are to what extent implemented by respective state forest institutions. For the first we use qualitative document analysis and structure elements of the analytical forest-related policy program for the each case on the base of the common priority goals. For the second we rely on the 3L-Model as a theoretical base and use criteria and indicators approach to evaluate institutions' performance in the goal implementation. Our results indicate many similarities in both, programs and institutions' performing, but also some considerable differences, as in the Slovenian case. We discuss state of the art and address respective future perspectives.

state forest institutions, forest policy

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IUFRO17-2617 **Strategic options for state forest institutions in Poland. Evaluation by the 3L Model and ways ahead**

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(1) Norwegian University of Life Sciences, Ås, Norway; (2) University of Novi Sad, Novi Sad, Serbia; (3) University of Göttingen, Göttingen, Germany

Abstract: State forest institutions in Poland, where 80% of the forest is state-owned, bear high responsibility for the sustainable development of this natural resource and strive to fulfil economic, ecological and social goals. To examine how far these goals are met and which strategic option(s)can be identified for the future the 3L Model was applied and comprehensive performance of the State Forests National Forest Holding (State
Forests) and the Ministry of Environment evaluated. The field study relied on a mix of techniques and the data, collected 2014 and 2015, showed the achievements of both institutions clearly: (i) the requirements of sustaining forest stands are met in practice; (ii) the State Forests makes profits and has enough resources for the active management of forests and goal achievement, thereby establishing some independence from the public budgets; (iii) the improved cost efficiency could vastly contribute to the stability of the State Forests, which is true for its marketing and the fact that innovative forest products have not been put forward yet; (iv) both the State Forests and the Ministry complement each other in the role of a speaker for forestry, which can contribute to making forestry more visible in media and political discussions; (v) mediating all conflicting interests in the forest is not a goal that is strongly followed by forest institutions in Poland yet.

Poland, state forest institutions, C&I

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IUFRO17-1171 **The restitution process in the Czech Republic and Slovakia. Directed the same beginning to the same results?**

Jarský, V.* (1); Dobsinská, Z. (2); Sarvasová, Z. (3); Sálka, J. (2); Oliva, J. (1); Hrib, M. (1)

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Abstract: Czech Republic (CZ) and Slovakia (SK) are countries which formed up to 1993 a federal state. Common social changes resulted in the restoration of private property also. Based on the federal law, restitution of the property collectivized by the communist regime was enabled, including forest property. Due to political and societal changes the federation was separated at 1.1.1993 and two new national states were created. The main research question we address is whether the process of forest property restitution followed similar steps (due to the same legislation) or ran differently (due to the creation of new national states). The methodological approach consists of the combination of relevant strategic documents and legislation analysis and qualitative interviews with actors involved in the restitution process. The main finding is that the original common legislation led (due to same procedural rules) to a similar result. Minor differences arose due to subsequent legislation and partly by specific historical forms of ownership. Main difference occurred within the restitution of the church property. While in SK churches were considered as standard restituents, in CZ the separate process of the church property took place, whose purpose is the complete separation of the churches from the state.

restitution, ownership, Czech Republic, Slovakia

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IUFRO17-1103 **The state and focus of forest ownership and policy research in Estonia**

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Abstract: The transition processes in Central and Eastern European countries have provided researchers with a variety of issues to study, creating good preconditions to conduct forest policy research. However, there are also research capacity issues in forest ownership and policy research, therefore this research has been quite fragmented in Estonia. Even more, a broad overview about the developments, current state and future prospects of private forest ownership, research and management in Estonia is still missing from the research community. This current review aims to fill this gap and provide a retrospect about research in this field and describe the different developments in the sector based on 23 reviewed scientific papers. These studies are analysed in more general framework - land reform, property and tenure rights, structural changes in forest policy, changing forest owners and ownership and forest management and cooperation. All these issues are discussed in both broader and local contexts as we focus on the specific topics, but also to research needs. We find that most of the earlier studies in 1990-es are too general and merely focus on giving a brief overview about the current state. Only during the recent decade forest policy and ownership research has gained more attention and has diversified in terms of applied research methods, specific topics and the nature of the data. Regards the sectoral developments, we find that the applied policy tools are mostly regulatory. Private forestry in Estonia is still quite over-regulated and influenced by the state, and, in general, it follows similar processes as in other Central and Eastern European countries.

management, governance, NIPF, private forestry

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IUFRO17-3298 **Forestry in transition: A review of forest policy research in the post-socialist realm**

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Abstract: After departing from the socialist past, Eastern European countries went through radical transformations of all societal facets including forest governance. Although 25 years have passed, a comprehensive review of the forest policy research is still lacking. Our study fills this gap by reviewing forest policy studies in 11 transition countries since 1990. First, a bibliometric analysis will provide temporal and geographic distribution of research topics and scientific affiliations. Second, a qualitative analysis of contents will discern the thematic and methodological priorities, digging deep into the main issues of concern.
The analysis will provide a structured overview of benefit for the community of forest policy scientists. The fact that this review draws on differences as well as on similarities, opens the way for collaboration, sharing solutions to or experience in common issues. The paper will address the intrinsic need for critical self-reflection by researchers as well as the extrinsic need for more critical orientation of research, purporting the exposure of essential problems and deliberate effort for their resolution.

Forest policy; research analysis; phronesis;

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IUFRO17-2027 **Reimagining forest policy, institutions and instruments according to societal expectations the focus on Ukraine and beyond**

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Abstract: In this paper, we apply participatory and analytical social science techniques to investigate how to embrace complexities and meet challenges of sustainability in the Ukraine's forest policy design and implementation. Moreover, we compare the state of the affairs in Ukraine's forestry with recent policy developments in its neighboring Central and East European countries. Findings indicate that the reality in Ukraine's forestry doesn't fully correspond to high societal expectations. Illegal logging, corruption, not always sustainable management of ecosystem services, lack of transparency in the decision-making, economic consequences of the ban on round wood export, and other observed phenomena have raised public concern, including of NGOs, mass-media and local communities. Consequently, forest conflicts have increased, and prevailing attitudes towards the forestry profession worsened. Institutional transformation is ongoing. However, the rules of the game have not changed noticeably. Proper administrative and financial decentralization has not been achieved. Forest policy remains state-oriented and following the top-down approach. There is a lack of forest policy harmonization and cross-sectoral coordination. Although market instruments have been increasingly applied, there is a room for deliberately involving civil society, as well as public and private sector actors. The results of analysis of the design and operationalization of numerous (and often contradictory) policy documents indicate that the (formal) institutional environment predominantly doesn't take into account a range of ecosystem services and possible implications of climate change and global changes on Ukraine's forestry. We conclude with the ideas on innovative instruments, including certification of natural assets which would allow the certificate holders to access emerging markets, serving as stimuli for responsible management, maintenance and use of forests.

institutional transformations, ecosystem services

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IUFRO17-1705 **The command-and-control model of forest governance in Lithuania and Slovakia: past, present and possible future.**

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Abstract: Being the countries with socialistic past, nowadays both Lithuania and Slovakia are going through the transition phase in many industrial and economical spheres. As a complex industry, forestry and forest management are strongly affected by the social and economic changes from many sides. However, despite the large-scale economic liberation and capitalisation, forest sector still stays under the command-and-control model. Regardless the growing amount of private forest properties, in both countries there is a strictly centralized forest management system, denying the decision freedom of forest managers and private forest owners. This presentation is aimed to give a wider view on the command-and-control forest administration systems in Lithuania and Slovakia, analyse their similarities and differences and suggest the possible alternative approach to the forest governance in both countries. The study is based on the data from EU Horizon 2020 project ALTERFOR.

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IUFRO17-1803 **Current problems in cross-border cooperation of Ukraine and neighboring countries in the field of sustainable forest management**

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Abstract: Efficient use, protection and reproduction of forest resources are the most pressing environmental, economic and legal problems in the border regions of Ukraine and neighboring countries.
Today, the main problem of unsustainable use of forest resources and inefficient efforts towards its conservation in the border regions of Ukraine and neighboring countries caused by the lack of societal understanding of priorities for the environmental conservation of environment and the benefits of sustainable forest management. In this regard, solving complex problems in the forestry sector in the border areas require to form a new ecological and economic vision, new ethical priority values, and new regulation to provide science-based concept of sustainable forest management.
Providing the conditions for sustainable forest management in the border regions of neighboring states is possible only by greening the economy and greening of education aimed at training for sustainable development.
In Ukraine, the need and prerequisites for greening the economy, greening of education through the training for sustainable development is included in a number of regulations.
Ukraine has to make a lot of environmental and economic efforts aimed to establish effective cross-border cooperation on sustainable forest management in the border regions of Ukraine and neighboring countries. This is due to the necessity of closer cross-border cooperation in terms of European integration.

forest management; cross-border cooperation

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IUFRO17-895 **Landscape Forestry in the Tropics**

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Abstract: Tropical forest landscapes play an essential role as hotspots of biodiversity in addition to providing important transboundary regulatory functions. They are essential pillars for rural economies providing timber and non-timber forest products as basis for livelihoods in developing countries. Despite global efforts, deforestation is still ongoing, especially in the tropics putting ecosystem services and livelihoods into crisis. In order to balance global and local demands on tropical forest ecosystems it appears essential to apply approaches integrating different spatial scales for the analysis of deforestation drivers, the consequences for forest related ecosystem services as well as giving recommendations for an effective allocation of appropriate policy instruments. In this presentation we introduce the landscape approach project LaForeT: "Landscape Forestry in the Tropics". The objective of the project is highlighting the impact of policy instruments on deforestation and afforestation processes as well as land-use dynamics and sustainability in a landscape context in the tropics. Analysis socio-ecological systems, governance aspects and incentive systems are cross cutting themes from national to local level. The project is implemented in Ecuador, Philippines and Zambia representing countries of different tropical continents and different stages along the forest transition curve. In every country twelve landscapes have been selected for analyzing the influence of restrictions for access and use regimes for tropical forests on forest cover, forest use potential, livelihoods of local communities, and opportunity costs as driver of deforestation across different spatial scales. The presentation will introduce conceptual and methodological principles of the project as fundament for science-based policy advice. On basis of preliminary results we will finally discuss the potential of landscape approaches as platform for bridging the science-policy gap.

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IUFRO17-4062 **How opportunity costs are linked to deforestation patterns in tropical Ecuadorian landscapes**

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Abstract: The conversion of tropical ecosystems to support basic needs has resulted biodiversity loss, decrease of ecosystem services, climate change acceleration, and decrease the quality of life of local rural populations. Some authors suggest that economic incentives could explain the forces that lead to tropical deforestation, meaning that land use decisions taken at different levels can be economically motivated. If this is true, the conversion of forests into non-forest land uses will occur when the potential benefits that can be obtained through alternative land uses, are higher than the expected benefits of forest conservation. In this sense, if we want to conserve the forest, local populations have to give up the potential benefits of the next best alternative of land use; these forgone benefits are known as the opportunity costs (OC) of forest conservation. In this study, OC will be calculated through net present values (NPV) derived from alternative land uses, under the assumption that in a certain area and time deforestation occurs when expected NPV of non-forest land use types are positive; and viceversa. The study focuses in decisions taken at a local (household) level, consequently NPVs will consider the most important land uses for local people, those that contribute with the highest percentage to the local economy and those that occupy the largest area or that might be pushing forests. The study is been developed in three places of high deforestation dynamics in Ecuador (Esmeraldas, Napo and Pastaza), where household surveys are been applied. At the end it is expected to have a spatially explicit distribution of NPVs that can be overlapped with forest cover change occurred in the last years, showing the context in which NPVs have been a driver of deforestation. This will allow to identify where deforestation is taking place due to economic reasons and where economic incentives will be a good strategy to reduce or stop deforestation.

tropics, deforestation, Ecuador, net present value

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IUFRO17-4072 **How different forest uses influences on ecosystems services on the tropical wet forest**

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Abstract: Tropical wet forest provide several ecosystems services for example it contain about 40% carbon in the terrestrial biosphere, but nevertheless forest cover has been altered by anthropogenic activities across the landscape, which have result in ecosystems degradation and fragmentation.
The present study is been developed in the Ecuadorian amazon basin ecosystems, in the last decades tropical wet forest had suffered a continuous degradation. The main driver of change is closely related to deforestation and land use change mainly to crops and grasslands, roads and growth population, which result in the reduction of carbon stocks. The present study seeks to understand the impact of forest uses in landscapes of different access regimes on ecosystems services as regulating services (carbon), the effect of facto uses and de jure restrictions will be analyzed in relation to disturbances intensities on the tropical wet forest. Through workshops we will identified the main forest uses using different participatory approaches as mapping and focus group discussions. A stratified random sampling will be use. Inside each one of the forest uses we will calculate different carbon pools (above ground, litter, deadwood and soil organic carbon), plots of 1600 m2 will be install and all trees from 10 cm DBH will be measure. We will find if indeed conservation strategies help to maintain ecosystems services as carbon and how the different forest uses will impact on them. This will serve as inputs to develop strategies aimed to promoted sustainable forest management in the tropics.

Ecosystems services, conservation, tropical forest

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IUFRO17-3344 **Livelihood strategies among migrant settlers and indigenous population in the Ecuadorian Amazon: an element to landscape approach**

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Abstract: This work examines the livelihood strategies (LS) of two ethnic groups and explores their implications for forest conservation in the context of landscape approach. We used data from household and community surveys covering migrant colonists and indigenous (Kichwa) people in the Sumaco Biosphere Reserve (SBR) in the central northern Ecuadorian Amazon. Data were collected using the Poverty and Environment Network methodology of the Center for International Forestry Research (CIFOR-PEN). To estimate LS, income proportions of farm portfolios were used in a Principal Components Analysis (PCA) followed by an Agglomerative Hierarchical Clustering (AHC). The results identify four LS: forest income, crop production, livestock production and wage labor (off-farm income). Income and household assets were calculated and compared for each LS. Results of a Tobit regression show that greater access to physical assets (land) increases income among households with forest-based LS. Kichwa show annual crop income being by US$ 223 higher under crop-based LS. In contrast, colonists earn, on average, US$ 472 per year more from livestock than indigenous households in livestock-based LS. Households with greater human capital (higher levels of education and more family members) are more engaged in wage labor-based LS. Households with livestock as their main LS obtain higher incomes, but also have the smallest mean area of forest remaining on their land, due to the extensive operation that requires the conversion of forests into grassland. Finally, the implications of the different activities in each LS for land use, conservation and multiple landscape approaches are discussed.

Livelihood strategies, incomes, landscape, Tobitl

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IUFRO17-3375 **Carbon Storage of Various Land Uses in Eastern Visayas, Philippines**

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Abstract: The Philippines is one of the countries most vulnerable to impacts of climate change. It is composed of many islands with varied topography, land cover and land uses which may contribute to the vulnerability of the region. Eastern Visayas is composed of three islands namely: Biliran, Leyte and Samar which are frequently visited by strong typhoons, and with high deforestation rate. The total forest cover of this region is half a million hectares. Baseline information on the carbon stocks of these forests and other existing land uses is still limited. This paper presents available data on carbon storage from various studies conducted mainly from tree-based systems including agroforestry, plantations and second-growth forests. Research gaps and the potential of existing land uses to sequester and store carbon will also be presented. Findings may be useful for policy recommendation gearing towards more appropriate land uses and more resilient sites in the region.

land use, carbon storage, Eastern Visayas

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IUFRO17-4110 **Integrated Natural Resources and Environment Management: Synthesis of State of Knowledge and Practice from the Philippines**

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Abstract: Natural resources and environment management is at the core strategies for achieving 2030 Sustainable Development Goals (SDGs) SDGs. There is mounting evidence that a piece meal approach in pursuing economic development and addressing the degradation of various ecosystems is inadequate and ineffective and may undermine the achievement of SDGs. One holistic approach is the conduct of interdisciplinary process that addresses too broad or complex question, problem, or topic that cannot be adequately dealt with by a single discipline or profession and draws on various disciplinary perspectives by integrating their insights through construction of a more comprehensive perspective. Such is the approach espoused by integrated natural resources and environment management or INREM. A central tenet of this approach is the interconnectedness of the problems of ecosystems and the human systems and hence the solution towards sustainability. Specifically, INREM puts forth a systemic and holistic approach to problem analysis and solving using appropriate analytical unit such as watershed/river basin, landscape/seascape, and small island through an interdisciplinary perspective. Drawing from selected paper contributions in the INREM national and international conference held in the Philippines in 2014 and early 2017, respectively, and other relevant literature, this paper synthesizes the state of knowledge and practice of INREM in Southeast Asia with focus in the Philippines. Specifically, the paper describes the history of natural resources management and current status of INREM and evaluates current INREM practice, including assessment methods and tools. The paper concludes by presenting key strategies on how IREM can help achieve SDGs.

natural resources management, interdisciplinary

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IUFRO17-4039 **Revisiting change in the miombo: uses and problems**

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Abstract: Miombo woodlands cover 2.7 million km2 of land across eastern and southern Africa. Much of these woodlands are located in customary lands. The woodlands are central to the livelihoods systems of 100 million people. Resource abstraction from these woodlands has largely been unsustainable and inefficient and across the miombo countries, deforestation and degradation rates are high. The marketing and improvement of processing techniques of various miombo products are inadequate and have little impact on people's lives. The different land tenure types and variations in settlement patterns, human population densities and land use systems have also had an impact. In addition, drivers of changes in the composition of the Miombo woodlands have reduced the capacity of this ecosystem to support livelihood systems practiced within it. Through literature search and review of case studies we ask the question "Can the Miombo woodlands, with all the changes occurring continue to support rural livelihoods while maintaining the integrity of the Miombo ecosystems?" Results show that governance structures and political regimes' decisions on the management of woodlands are impacting on both livelihoods and the resources base. Rural communities have been inactive in terms of reversing the trend.

miombo woodlands, livelihoods, change, governance,

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IUFRO17-2601 **Applying ecosystem service approach in navigating forest contributions to rural livelihoods**

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Abstract: Forests and trees generate a broad range of benefits such as food, wood energy and income as well as stabilise soils and climate, and regulate water flows for supporting food productions. But in the contemporary research, there are more focuses on the direct economic contributions of forests to livelihoods with a less focus on indirect services. So we examined the importance of ecosystem service provisions of forests perceived by local people in the Chittagong Hill Tracts (CHT) region of Bangladesh. Over the recent past years, the region has passed through forest and land use changes that have diverse effects on ecosystem service provisions and livelihoods. Guided by sustainable livelihoods and ecosystem service concepts, we carried out interviews with 210 rural households, key informants and focus groups on the social and environmental contributions of forests in CHT. Most of the surveyed respondents in the study perceived the provisioning services were essential for their food, firewood and timber. Regarding indirect benefits, they mostly prioritised regulating and supporting services such as watershed conservation and soil protection to be important for improving local food productions. However, the perceptions of the respondents on ecosystem service provision are relatively different within the socio-economic groups, the level of proximity to diverse forests management systems and changing tree-based land uses at the landscape level. People living within proximity to natural forests appreciated more ecosystem services than those depend on planted forests and agroforestry practices. Diverse perceptions indicate the different goals of the forest and land management exist at local and regional level. Drawing the lessons of the study, we recommend ecosystem service concept might be useful tools in enhancing synergies within the management interventions to sustain the critical benefits of forest in rural livelihood at the landscape scale.

Land Use, Landscape, Chittagong Hill Tracts

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IUFRO17-3248 **Forests, food and nutrition: A policy perspective**

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Abstract: With a growing global population, much of the current discourse on food security is focussed on increasing and expanding agricultural production. Much of this expansion is speculated to be at the expense of natural systems. However, forests and tree-based agricultural systems contribute directly and indirectly to the livelihoods of an estimated one billion people globally. Wild foods are important for food security and nutrition while trees and forests are vital for their role in the provision of ecosystem services to agriculture. Despite this, the role of forests in supporting human food security and nutrition has, until recently, remained largely under-researched and understood. With food security and nutrition high on the agenda in many political and scientific spheres, it is crucial to understand the contribution of forests and trees to a food secure and nutrition-sensitive future.

In addition, evidence is required on the contribution of forests based ecosystems service in order to ensure forests and biodiversity conservation remains on the agenda of policy makers and practitioners in conservation, agriculture and nutrition. The dearth of empirical descriptions and quantification of ecosystems services to agriculture limits the inclusion on initiatives related to the sustainable intensification of agriculture for example and in depth studies could contribute to a better understanding on the trade-offs between land sharing and land sparing as strategies for future food production.

This paper will present the findings of two global assessments (IUFRO, GFEP and the HLPE of the CFS) of the linkages between forests and food security and nutrition and provide a series of policy recommendation to better integrate forestry, agriculture and other land uses at the broader landscape scale.

Forests, food security, nutrition, landscapes

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IUFRO17-676 **Sustainable Forest Management translations in a global-local nexus: an institutional analysis in Caatinga biome, Brazil.**

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Abstract: Sustainable Forest Management (SFM) has gained traction across different governance domains as a strategy to manage forest resources while maintaining various ecosystem services. When implemented, SFM needs to respond to different aims, goals and interests across different scales of governance. As such, the idea of SFM may be subject to a series of translations: across different levels of governance, across different social-ecological contexts, and to specific forest practices on the ground. The present paper, through an institutional lens, explores how SFM translations influence forest governance outcomes and practices in a specific social-ecological context, Caatinga biome in Northeast Brazil. First, the paper explores how SFM is interpreted and translated from the global to the Brazilian national scale of governance. Second, it analyses how SFM is translated to implementation strategies at the governance level of Caatinga biome. Finally, the paper explores how, in a local scale, SFM related institutions become subject to a bricolage processes, and to what extend these processes shape forest governance and SFM practices in Caatinga biome. We found that the success of SFM translations from a global to a national level of governance depends on policy and domestic contexts in which it is inserted. When translated to a specific social-ecological context, SFM implementation strategies are shaped by social actors interactions happening through a system of norms, rules, and beliefs. Finally, we found that SFM practices on the ground are mainly translated through a bricolage process of already existent institutions, resulting in a dynamic implementation strategy, which varies according to the social-ecological context of local communities involved. The analysis of SFM institutional translations contributes to a better understanding of the influences institutions on policy outcomes in a specific social-ecological context, such as those related to biomes.

Sustainable Forest Management; Caatinga biome

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IUFRO17-1988 **Renewable energies policy in Uruguay: the case of the Northeast region**

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Abstract: The debate on the promotion of renewable energies and its link with sustainable development has been present in the literature since the last decades of the XX century. In South America, some countries have passed policies in order to address their energy issues. Since 2008 Uruguay has developed several policies with the goal of diversifying the energy matrix with a stronger focus on renewable energies. The investments in this sector are estimated in 7 million US dollars. In that benchmark, the objective of this research is to characterize the renewable energies sector in the Northeast region of Uruguay in order to analyze the contribution of new energy policies to local development. Historically, the Northeast region of Uruguay has had poor economic and social indicators compared with the rest of the country. However, many forest investments (biomass power plants and eolic parks) are now located there. From a qualitative approach this paper analyzes the perception of stakeholders regarding the presence of "new" energy in the region, asking in which way this process is linked to the development of the territory. The results show that most of these actors perceive the development as positive and indicate significant spillovers effects on local economies.

sustainable energies, renewable energies, Uruguay

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IUFRO17-272 **Past, present and future of forest policy in Chile**

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Abstract: From the time of the conquest, in order to meet the needs of mining and expand the agricultural frontier Chilean native forests were subjected to an irrational exploitation. In the twentieth century the Chilean government began efforts to recover degraded soils and installed public institutions designed to promote forest plantations and industry.
Today, Chile's forestry situation is showing contrasts. On the one hand, there is a forestry sector based on 2.5 million hectares of mainly pine and eucalyptus plantations, which produce annually more than 40 million m3 and allow the export of more than six billion dollars. This business mostly held by large companies has been criticized for adverse social and environmental impacts.
On the other hand, about 14 million hectares of native forests remain largely subject to degradation processes. This results in low economic value, impoverishment and decapitalization of the mostly small and medium size native forest owners.
In order to correct the current asymmetry and potentiate forestry, all private and public stakeholders defined during 2015 and for the first time in Chilean history, a forest long term State policy. There is full consensus on the need to initiate a new cycle of forestry development in Chile. A major challenge is addressed through four broad objectives: forestry institutions have to adapt to the times, increase productivity and economic growth, improve social inclusion and equity, as well as the protection and restoration of the forest estate.

Chile, policy, development, plantations, native f.

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IUFRO17-3150 **Critical analysis of the forest policy development in Argentine and some incidences on the Delta del Paraná transformations**

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Abstract: The paper aims to analyze the development of forestry policies in Argentina and trace some reflections about the Delta del Paran á socio-economic transformations due to these policies.

Our revision showed that forestry is one of the agro-industrial subsectors that has been subject of an unusual un-interrupted economic and technological support by the State for more than seventy years. Moreover, the revision of laws and promotion programs enabled us to identify, that some constituent elements of the discursive argumentation as well as of some instruments of application of these policies remain valid from the period of Substitution of Imports (1930-1970). Based on a qualitative analysis of documents and interviews it has been possible to observe that a diagnostic based on a negative trade balance, the need of the industrial and labor development, still orient the definition of forestry expansion instruments in the current public policies such as the Law of Promotion of Cultivated Forests(Law No. 25080 passed in 1999 and extended until 2019)

At the territorial scale, in the last decades a rapid process of socioeconomic transformation in the Paran á Delta was registered, which, according to several studies, correlates among other factors with the expansion of forestry started in the 1970s. An increase of the scale of production and the emergence of new industrial producers with high technology and capital investment correlate with the disappearance of family producers. In this context, the paper also explores the incidence of the public policy frameworks in the Delta del Paran á region.

Forest Policy; Delta del Parana; Argentina

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IUFRO17-2755 **Actors' perception on future wood production in a cross-border amazonian region: challenges for a sustainable production**

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Abstract: We conducted a study in a cross-border region of Amazonia to analyze the future role of natural forests in producing wood products. French Guiana and the state of Amapa are sharing similar geographical properties. A predominant area of these two territories are dominated by undisturbed tropical forests. In both regions, over 70% of forest areas is under public ownership. Currently the forestry sector in both regions do not have a key role in local economies, with low legal wood production in French Guiana (75 000 m3) as well as in Amapa (around 120 000 m3). Although in Amapá there is a high level of illegality in the sector (85%).
In French Guiana and Amapa, forestry activities might represent an economical opportunity to promote endogenous development. The forest sector, including private and public actors, will face strategic choices to respond to increasing demand in wood supply for the coming decades. Strategic choices, based on strong political decisions, include the volume of wood to be produced locally, type of actors involved (i.e. communities, private companies), type of production (timber vs fuelwood) and origin of wood (plantation vs natural forest).
Based on a prospective approach, we identified various scenarios, for each region, to reach the wood supply by 2045. First, we interviewed key actors of the forestry sector to obtain the view from their perspective. Second we selected the key variables to construct the scenarios and validated the resulting scenarios through a discussion with all actors.
The scenarios identified in French Guiana had the implementation of tree plantation with local species as alternative to natural forest management, while in Amapa they focused on forest management associated with public policy and social factors.
These scenarios are providing a framework of discussions that could help actors to focus on long term and to imagine the likely impact of current policy choices on the socioeconomy and conservation of natural forests.

forestry,French Guiana,Amapá, prospective.

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IUFRO17-1151 **The role of International and Transnational organizations in Latin American forest policy. The case of Argentina**

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Abstract: In recent decades, globalization and internationalization led to an increase in the number of international regimes attempting to influence national behavior over many different issues. By using the case of the international forest regime complex this study seeks to evaluate how an international organization such as the World Bank and private institutions of forest certification influence domestic forest policy in a Latin America context. The case of Argentina was selected as an example of a Latin America, federal country open to international influences with a weak forest sector that went through a recent administrative restructuring. In so doing this study seeks to answer how do international and transnational organizations influence domestic forest policies?
The study focused on two main sources of data: written documents and semi-structured interviews with experts. In total approximately 50 interviews were carried out, between October 2012 and September 2014. In addition around 100 documents from both public and expert sources were analyzed in the same time period. Process tracing was used to understand how international and transnational organizations influence policy change in the domestic level through direct access and market mechanisms. In all cases data was analyzed by means of qualitative content analysis.
The results show that: the influence of the World Bank in Argentina pushed the forest sector towards deregulation; state bureaucracies play an important role in the implementation of transnational regimes at the national level; the political system of federal countries provides multiple institutional access points for policy change that international and transnational regimes try to use in order to influence the domestic level, consequently changing the power balance of the domestic networks.

Argentina, Forest policy, Federalism

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IUFRO17-2410 **Twenty five years of forest policy and governance in Costa Rica, tradeoff between discourse of conservation and sustainable forest management**

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Abstract: The time line in Costa Rica forestry policy started in 1969 (law #4465) when was sign the first law related to forest in the country. The research time period of interest is from 1986 to 2015, it could divide in three phases first CAF period (1986-96), PSA period (1996-2000), and REDD+ period (2000-2015); each period was addressed by a different group of stakeholders that dominance the policy discourse, authors such as Lecop et al 2013, and Corbera 2009 remark the issue, and elements as well as equity, legitimacy, institutional dimensions, and the role of street level bureaucrats involved in the decision making process in each policy. It is important to understand and evaluated this through effects on forest owners, forestry industry sector, the provision of ecosystem services, communities and other interrelated sectors to figure out what is the best scenario for policy decision making?. The study evaluates and shows the influence of stakeholders through action and effects in 25 years of forest policy and propose the decision making scenario for forest innovations.

forest policy decision making stakeholders

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IUFRO17-1481 **Major bottlenecks in the regulation of the Environmental Reserve Quotas in Brazil**

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Abstract: Context

The Brazilian Forest legislation requires all private rural properties to maintain a fixed proportion of their area as forest in the form of a Legal Reserve. However, Forest Law No. 12,651/2012 provides mechanisms of flexibility for landowners who, as of 22 July 2008, did not have the area-based conservation requirements of the law, by compensating this Legal Reserve deficit in other properties. One of these possibilities involves the issuance of an Environmental Reserve Quota, known in Portuguese as CRA

Specific problem

Why has the Government taken so long in regulating the CRAs? What are the stages, bottlenecks and controversies that have hindered the regulation of these quotas?
Methods
Bibliographic review, aid-memoire of minutes related to the regularization of CRAs; semi-structured interview with state and non-state stakeholders

Main results

Three points come before the regulation of the CRA: 1) settlement of the Rural Environmental Registry (know in Portuguese as CAR); 2) establishment of an monitoring system for the validation of the CAR. In addition, ever since the four years of the creation of the CRA by Law No. 12,651/2012, several bullet points have been the object of debate about this regulation, such as: the possibility of small landowners with no excess vegetation to issue CRAs; the possibility of CRAs being used for other purposes beyond compensation of Legal Reserve, such as payment for environmental services and the possibility of regulating CRAs in Conservation Units

Conclusions

Considering that the CAR has achieved 99% of area already registered and that the Brazilian Forest Service has designed a model of analysis of the declared CARs, as well as it is setting up a monitoring system, the Ministry of the Environment and the Brazilian Forest Service, in consultation with the stakeholders who have followed up on this issue, need to regulate the CRA so that it can make the most with the possible benefits on the environmental point of view

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IUFRO17-2891 **Incentives for woodland creation to improve water quality: an overview of the initial findings, activities and ambitions of the PESFOR-W COST Action**

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Abstract: The EU Water Framework Directive (WFD) aims to restore Europe's water bodies to "Good Ecological Status" by 2027, but many Member States are struggling to achieve this target. Around half of EU river catchments report below standard water quality and diffuse pollution poses long-term chronic risks for over a third of European freshwater bodies. Meeting WFD targets in a cost-effective way will require mainstreaming incentives such as Payment for Ecosystem Services (PES) schemes to deliver effective, spatially-targeted restoration actions.

Adopting a broad definition of PES, the new PESFOR-W COST Action aims to synthesize knowledge on existing PES schemes encouraging woodland creation to reduce agricultural diffuse pollution and improve water quality. Highlights from findings of initial reviews of evidence on the Environmental Effectiveness, Cost-Effectiveness and Design and Governance of existing PES schemes, along with those from other activities are noted. The latter include creation of a new spatial hub for woodlands for water PES case studies and a survey of aspirations of the Action's participants. Ambitions to create a European PES skills directory and to better link different strands of evidence on woodland creation in pursuit of goals of the wider carbon-water policy nexus are also discussed.

Payments for Ecosystem Services, forest, water

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IUFRO17-4019 **Engaging Utilities Companies in Water PES: first evidences from European case-studies**

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Abstract: Payments for Ecosystem Services have been increasingly proposed to address the provision of water regulation services by forests. PES have been suggested for solving water scarcity issues, reducing water pollution, improving drinking water, regularize water regimes for agriculture. Within the numerous existing initiatives, those focusing on drinking water seem the most promising, as the provision of drinkable water is based on a large and well developed markets, with numerous buyers and already established payment mechanisms. Besides, utilities companies seem to ripe clear benefits on water streams from planting riparian woodlands and buffer strips or compensating farmers for changing management practices. While cases of water PES are already at work in the USA since few years, in Europe they are still at a nascent stage, with few known examples.
Starting from here, the paper aims firstly at filling a knowledge gap on Water PES schemes in place in different European countries. This objective is achieved by means of a case-study based survey implemented in the countries participant to the PESFOR-W COST action and beyond, which will provide novel information and improve existing one. Secondly, taking inspiration from similar studies carried out in the USA (Bennet et al., 2014), the paper will explore mechanisms and models for engaging Utilities Companies in the implementation of Water PES schemes, developing the appropriate legal framework and identifying successful payment mechanisms. Data will be collected by means of semi-structured interviews to utility managers, governamental agencies, regulators and intermediaries. It is anticipated that the survey will provide relevant insights into the definition of more effective and efficient Water PES in the European context.

Bennett, D. E., Gosnell, H., Lurie, S., & Duncan, S. (2014). Utility engagement with payments for watershed services in the United States. Ecosyst. Serv. 8, 56-64.

PES; water; forest; utilities

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IUFRO17-3204 **Quantifying the effectiveness of woodland creation measures for reducing agricultural diffuse pollution**

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Abstract: Ninety percent of River Basin Management Plans across Europe identify agricultural runoff as the main source of diffuse pollution. On-farm measures to tackle the problem are increasingly being found to be insufficient to meet water quality targets. This is driving interest in targeted woodland planting as a more effective and secure intervention to reduce pollutant delivery to waters, while minimising land take and impacts on farming. Woodland offers a barrier and pollutant interception function, reducing the risk of direct contamination by agricultural activities on the adjacent land, as well as trapping and retaining nutrients and sediment in polluted runoff.

As part of the EU COST Action PESFOR-W, the evidence for the effectiveness of woodland creation for reducing a range of diffuse pollutants has been reviewed, with a focus on sediment, nitrate, phosphate, pesticides and Faecal Indicator Organisms. This paper reports the findings and describes how the results are being used to develop value ranges for woodland measures to reduce individual diffuse pollutants, and how these will populate look-up tables for use by pollutant and ecosystem services models. This will assist the development of payments for woodland water services as a cost-effective and sustainable approach to diffuse pollution management.

diffuse pollution, woodland creation, PES

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IUFRO17-3524 **Forest services to preserve drinking water: guidelines and partnerships**

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Abstract: It is widely recognised that forests play an important role in maintaining water quality, but they have to be cared for to make their protective role as effective and enduring as possible. This initiative of French private forest organizations involves associating forest managers in the achievement of good water quality for drinking purposes, through innovative contracting methods.

A first work in collaboration with INRA, developed methods to produce reliable economic figures on the environmental services rendered by forests. The issue of absorbing additional forestry management costs incurred to safeguard the water remains to be resolved. The second step aimed to draft contracts defining mutual commitments. Thus, contracts models are available. We also carried out technical projects to optimize forest practices: one main result is the publication of technical guidelines for forest management practices to protect drinking water resources. The third step was to validate partnerships at sites between private forest owners and water operators.
One particularly innovative example is the partnership with the SIEM (water management board in Haute-Savoie). To improve coordination between silviculture and catchments protection, the SIEM and forest owners formed an association. Initiatives introduced range from a concerted forestry management plan, to forestry operation specifications, which when implemented, grant entitlement to compensation.

Land use management is part of the process of producing drinking water. Private forestry organizations in France developed operational solutions to protect water quality. However, political support and improved communication are required before the model can be applied on a large scale. Foresters are ready to commit themselves, but they can't do it alone. Partnerships with water operators are necessary: in order to optimize protection of vulnerable catchments, and for an efficient and sustainable wood mobilization.

PES, drinking water, forest owners, guidelines

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IUFRO17-367 **A quantitative analysis of factors affecting the implementation of water-related PES schemes**

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Abstract: Intact ecosystems are essential for human well-being. However, the depletion of natural resources and the resulting global degradation of ecosystems are becoming more and more apparent. When ecosystem services and the benefits they provide are lost, it is challenging and often extremely costly to offset this loss. Most recently, striking evidence for this problem has been shown by the international TEEB initiative ("The Economics of Ecosystems and Biodiversity").
Payments for Ecosystem Services (PES) are basically incentives offered to landowners in exchange for providing some sort of ecosystem service. However, the many case studies of PES programs from all over the world do not provide a clear picture of the institutional-economic and ecological factors that are crucial for scheme implementation. The purpose of this study is to identify those factors that are decisive for the supply of water-related PES schemes in a specific country using a logistic regression model. In particular, we test the influence of institutional conditions like security of property rights, legal certainty, and corruption and ecological conditions like quality of drinking water and flood occurrence. This crossnational study could contribute to identify countries where future water-related PES schemes can be successfully established.

PES, crossnational analysis

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IUFRO17-865 **Comparing institutional characteristics of PES schemes for forests and watersheds: selected cases in Ecuador**

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Abstract: A number of Payments for Ecosystem Services (PES) schemes in Ecuador focus on forest conservation and watershed protection. Socio Bosque is a government-led voluntary program heavily dependent on governmental budget. It provides monetary incentives conditional on forest conservation activities. FONAG and FORAGUA are trust funds, composed of private organizations and local governments, relying largely on contributions from water bills. They provide technical support, as a non-monetary incentive, directed towards watershed protection. Although these schemes share environmental improvement as their ultimate goal, they differ in their design and implementation; government agencies design and implement Socio Bosque, whereas FONAG and FORAGUA require consensus among their participants for the design and implementation of programs. The type of incentive and the institutional framework under which these schemes operate expose inherent characteristics of their design and implementation that impact their environmental performance. A comparison of legal documents and statistical data present evidence on how cost-effective their performance is and the institutional characteristics of differently designed and implemented PES schemes functioning under similar socio-economic conditions. Identifying key political, economic and cultural characteristics hindering or promoting the performance of PES schemes permits the design of appropriate institutional prerequisites, the selection of an adequate incentive, and the optimal selection of potential beneficiaries of scarce financial resources.

PES, Ecuador, institutions, forests, watershed

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IUFRO17-2563 **Classifying Forest Peatlands and Holistic Evaluation of Ecosystem Services**

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Abstract: Most of the forest peatlands in South-West Germany are degraded by drainage and long-term forest management with spruce plantations. Restoration of these peatlands started already about 40 years ago, and recently is enhanced. Drainage ditches were closed, and spruce stands were changed to open peatlands only tolerating the natural rejuvenation of downy birch. As sphagnum moss needs very long time to rebuild a peat layer, renaturalized peatlands show different degradation and recovering states. With regard to their level of closeness to nature representative peatlands were classified pursuant to biodiversity indices, typical vegetation for peatland and water budget.
According to their wide range of closeness to nature the different ecosystem services of the investigated forest peatlands enter into competition between commercial interests by timber sale on one hand, and natural water retention and process conservation on the other hand. Wood production dominates in degraded and drained spruce peatland, whereas regulated water retention services and a high biodiversity of typical peatland vegetation dominate in close-to-nature peatland.
Such benefits will be assessed by involving different stakeholders such as forest owners, timber industry, and the very heterogenic group of nature conservationists or tourism enterprises and related groups. Each group of stakeholders has specific, but different interests in ecosystem services. All ecosystem services will be defined by intermediary functions with specific indicators. Thus, typical ecosystem services will be evaluated due to the close-to-nature classification and to the needs as required by stakeholders. This evaluation is the base of calculating compensation payments for providing natural retention areas to support flood risk management and enhancement of biodiversity. This opens the door for developing management options in forest peatlands and to exploit monetary value for changing ecosystem services.

peatland; water budget; restoration; evaluation;

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IUFRO17-1510 **Forest management decisions when timber, carbon sequestration and water yields have an economic value. An application to Alpine forest**

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Abstract: We present a modeling framework consisting of a forest management economic optimization model coupled to a spatially distributed eco-hydrological model (FORHYCS), which in turn couples hydrological and forest-landscape processes. We use this integrated framework to forecast the dynamic effects of economic-driven forest management decisions on annual catchment water yields and their seasonal distribution over the period 2020-2050. We apply this model to the Navisence River catchment (South-Western Swiss Alps), which covers an area of about 250 km2 with 50 km2 of glaciers, and elevations ranging from 600 to 4,000 m AMSL, allowing for spatial heterogeneity in forest species distribution, growth and production cost functions. We simulate optimal harvesting decisions for different sub-catchments, in view of the expected net timber revenues, carbon sequestration and water yields under different management options and climate change and timber demand scenarios. Two contrasting forest management options are examined: (i) a close-to nature management with higher species diversity and reduced thinning interventions and (ii) a timber-oriented forestry, characterized by lower species diversity and intensive management. We explore the effect of changes in the leaf area index and root zone storage capacity due to alternative management options on annual water yield, and account for potential payments for water provisioning services on optimal harvesting decisions.

optimal rotation age, climate change.

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IUFRO17-1594 **Models explaining the levels of forest environmental taxes and other PES-like schemes in Japan**

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Abstract: In Japan, between 2003 and April 2016, 37 of 47 prefectures (sub-national local governmental units) introduced forest environmental taxes, PES-like local schemes. The schemes are mainly intended to improve unsatisfactory levels of plantation-forest management, which are supposed to cause water-related problems such as droughts, floods, and landslides. This study empirically estimated models explaining the normalized expenditures from forest environmental taxes as well as other PES-like schemes (subsidies for enhancing forests' and mountain villages' multifunction; green donation) and the normalized traditional forestry budgets for Japan's 47 prefectures based on the median voter model. It was found that the median voter model had limited power in explaining forest environmental taxes. The past incidence of droughts and landslides are positively correlated with the introduction of forest environmental taxes. Residents' demand for the environmental services of forests was not positively correlated with the abundance of nearby forests. The more municipalities in a prefecture there were, the lower were forest environmental taxes and forestry expenditure. The numbers of forest volunteering groups, possibly an indicator of social capital in the forest sectors, had strong positive correlations with the levels of forest environmental taxes and forestry budgets.

PES, Asia, local governments, public finance

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91 - Interdisciplinary Perspectives on Illegal and Informal Logging and Related Trade: Drivers, Impacts, and

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IUFRO17-2106 **Defining illegal forest activities and illegal logging**

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Abstract: This paper discusses definitions of illegal forest activities and illegal logging that affect forest ecosystems, and draws implications for future research priorities.
The following questions will be addressed to in the analysis:
i.Which are the activities whose illegality has been considered in the context of forest management?
ii.How has the illegality of those activities been defined in the laws of specific countries?
iii.How can the equity of legal frameworks regulating forest activities in timber producing countries be ensured?

Drawing on the literature, a categorization of illegal forest activities and illegal logging is provided. The categorization includes an indication of the potential types of actors associated with them. This categorization, and the experience of various countries, indicates that it is counterproductive to conflate the concepts of illegal forest activities, illegal logging and informal logging.

It is also found that quantitative assessments of the extent of illegality in the forestry sector have mainly focused on the volumes of illegal timber. Consideration should be given to the collection of data on other illegal forest activities presented in this paper in order to fully understand the phenomenon, given that many illegal activities may be connected.

illegality, definitions, informality

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IUFRO17-960 **Timber, numbers and definitions: a proposal for a novel quantification and qualification of illegal logging**

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Abstract: For more than a decade now, illegal logging and related timber trade (IL) have been one of the defining topics of the global agenda on forests and the environment. Such prominence has resulted in significant innovations occurring in global, regional and national forest and trade regulations. Yet, IL remains fugitive in terms of definitions, impacted markets, and drivers. This maintains a high degree of uncertainty as to the extent of IL across different geographies as well as its impacts on and associated responsibility of stakeholders along the IL value chain. This paper i) reviews existing estimates of major legal and illegal timber trade flows and applies a transparent and replicable method for the assessment of IL, and ii) provides a novel insight on the growing extent of domestic timber markets, with case studies gathered from many tropical timber producing countries. We find that current annual estimates of international illegal exports of logs and sawn-wood reach about USD6.3 billion. Also, findings indicate that adopted regulatory definitions of IL in some countries have potential negative impacts that those regulations were set to avoid. We discuss several risks that exist in embedding domestic informal timber trade into currently used IL definitions, and argue for innovative policy instruments aimed at avoiding those risks.

Illegal logging, informal timber markets

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IUFRO17-718 **Multiple and Intertwined Impacts of Illegal Forest Activities**

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Abstract: There have been numerous country-level studies to assess the impacts of illegal logging and illegal forest conversion. Our current understanding indicates that these impacts are multiple and strongly intertwined across social, economic, political and environmental dimensions. The assessment of illegal forest activities' impacts is complicated due to three factors: firstly, there is no clear-cut boundary between impacts associated with legal versus illegal forest activities. Secondly, the impacts of illegal activities establish complex interactions among each other, resulting in diverse synergies and trade-offs. Thirdly, often it is assumed that all the impacts of illegal logging are negative but they can be positive as well. This paper identifies and characterizes the multiple impacts resulting from illegal forest activities drawing on existing literature on the topic. We propose a framework to understand these impacts and their causal relationships along different impact trajectories. This framework identifies three situations (and associated actors) under which illegal forest activities are practised, i.e. large-scale illegal logging operations linked to industrial processing, informal small-scale and artisanal production, and illegal forest conversion. We relate each of these situations to different types of impacts (i.e. direct, indirect and cumulative) occurring across different dimensions (i.e. social, economic, political and environmental), which determine different impact trajectories associated with the three dominant situations mentioned above. In addition, in order to illustrate these impacts, we examine cases of illegal logging activities in several countries in Latin America, Central Africa and Southeast Asia. These different cases enable us to draw conclusions about the characteristics, magnitude and nature of impacts across different impact trajectories linked to specific contextual factors.

Illegal Logging, Forest conversion, Impacts

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IUFRO17-472 **Drivers of Illegal and Destructive Forest Use**

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Abstract: Despite manifold efforts against, in many regions of the world illegal and destructive forest uses continue with unabated speed. This paper invests in understanding the reasons by exploring the rich stock of literature on proximate, underlying and immediate drivers of deforestation and illegal logging. The analysis reveals that illegal and destructive forest use is driven by several mutually reinforcing factors. People make decisions to maximize individual benefits and insufficiently consider externalities. Their decisions are embedded in a societal context characterized by unequal distribution of power and wealth that allows economic elites and better-off societies to enforce their interests. Within this context, illegal and destructive forest uses are often more practicable and attractive than those that are legal and sustainable. This already problematic situation is expected to worsen in the future. A number of shortcomings place limits on the success of initiatives to improve forest governance, namely: the problem of corruption, deficiencies in the design and performance of regulations and enforcement institutions, as well as the existence of some strategic errors, particularly, the emphasis on larger timber companies and export markets, and the insufficient consideration of the potential and needs of customary forest dwellers active in informal market networks.

Landusers, decisionmaking, development, governance

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IUFRO17-2448 **Actors and Hidden Incentives in Nepal's Community Forest Timber Value Chain**

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Abstract: Taking the case of Sal (Shorea robusta) timber trade from community forests, this paper describes about rent seeking collations among the actors on chain of custody. This research was carried out in 36 timber trading community forest user groups followed by intensive observations in four community forests and in-depth interviews with some 100 actors along the timber supply chain. Three actor have colluded together; (a) direct actors, e.g. user groups, agents/contractors, saw mill owners (b) regulating actors, e.g. forest bureaucrats, and the police, and (c) influential actors, e.g. local youths/gangs and political leaders. The contractors have high profit margins (almost 50%) and nurturing collusions. They manipulate officially intended fair, transparent and competitive processes by making pre-investment on harvest; mobilizing local youth; manipulating bureaucratic requirements; providing logistics support and colluding with other contractors to avoid competition and secure bid at lowest possible price. The cost price analysis reveals that hidden costs, such as donations, allowances and incentives accounts for one fifth of saw mill gate price, which are shared between regulating (48%), influential (42%) and direct actors (10%). The study concludes that all actors are using their regulatory, resource endowment, social or muscle power to extract rents from community forest timber.

Actors, Collations, Incentives, Trade

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IUFRO17-3699 **Global governance approaches to addressing illegal logging: uptake and lessons learned**

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Abstract: One of the most challenging tasks for those seeking to ameliorate illegal logging is to identify promising global governance interventions capable of helping improve compliance to governmental policies and laws at national, subnational, and local levels. This article seeks to shed light on this task by asking four related questions: How do we understand the emergence of illegal logging as a matter of global interest? What are the types of global interventions designed to improve domestic legal compliance? How have domestic states responded to these global efforts? What are the prospects for future impacts and evolution. We review the emergence of problem of 'illegal logging' on the international agenda and the interventions that resulted from this policy framing. Second, we assess uptake in consumer (United States, Europe); middle of supply chain manufacturers (China and South Korea) and producer (Russia; Southeast Asia, especially Indonesia; Brazil and Peru; Ghana, Cameroon and the Republic of Congo) countries. Third, drawing on this analysis, we conclude by offering ideas about what strategies stakeholders may want to pursue to foster global governance efforts towards reducing illegal logging across global supply chains and within domestic settings

Illegal logging, legality verification, governance

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91 - Interdisciplinary Perspectives on Illegal and Informal Logging and Related Trade: Drivers, Impacts, and

KG I - 1098 (Uni Freiburg)

IUFRO17-2393 **The Impacts of the EU Timber Regulation: Market Diversion and Product Substitution**

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Abstract: The EU Timber Regulation was adopted in October 2010 and enforced in March 2013, to prohibit the placing of illegal timber on the EU market. In this paper, we use quarterly trade data to quantify the impacts of the EUTR on the import quantities by EU Member State and by product. After controlling the effects of macroeconomic factors, our results show that most north and central EU countries significantly decreased their imports in tropical and temperate timber products. Furthermore, the United Kingdom and some southeast and south-central EU countries significantly decreased their imports in tropical timber products while increased the imports in temperate plywood. However, significant increases in the imports of tropical wood have been observed in western and north-central EU countries.

Illegal logging, trade diversion, EUTR

KG I - 1098 (Uni Freiburg)

IUFRO17-1917 **The Importance of Strengthening Governance for FLEGT and REDD+ Implementation: Why illegal logging remains a central challenge**

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Abstract: Nations and stakeholders are moving in 2017 to implement two key international agreements. First, efforts are moving into high gear to implement the Paris Climate Agreement as it relates to forests and deforestation, the so-called "REDD+ Agenda". Second, the Voluntary Partnership Agreements ("VPAs") between the European Union and various timber producing countries, are reaching the implementation stage after years of negotiation under the EU's Forest Law Enforcement, Governance and Trade(FLEGT)Action Plan. The first "FLEGT-licensed timber", from Indonesia, began to flow in November 2016.

Success for both of these major international forest policy initiatives depend on improving governance on the ground in key producer nations:

* REDD+ cannot move beyond the development of action plans and the issuance of "stroke of the pen" policy measures, to credible "pay for performance" emissions reductions when illegal logging and corruption are widespread in relevant countries and forest areas. Potential private sector REDD+ investors will shy away from such high-risk countries, and the constituencies of major public international donors will not stand to see their money frittered away in places where deforestation cannot actually be reduced due to governance weaknesses.

* The FLEGT agenda depends on the development of robust "chain-of-custody" timber legality assurance systems, and progress has been made in developing such systems. However, even robust systems can be gamed and cheated to "launder" illegally-cut wood, and this is a likely outcome where such systems are activated without dealing with underlying issues of corruption, abuse of power, and weak controls over illegal harvesting.

This session will be a "talk-show" format, in which the two chairs, Head of the WRI Forest Legality Initiative and the FAO FLEGT Program respectively, will engage a diverse panel of experts from key forest countries on the challenges and solutions for dealing with illegal logging.

Illegal Logging, Governance

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IUFRO17-1128 **Spatial and temporal trends of forest cover as a response of policy interventions in the district Chitral, Pakistan;**

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Abstract: Forest cover changes are one of the most important land cover change processes and have been of great concern to policy makers. Repeated remote sensing survey is a crucial tool for understanding how forests change in response to forest protection strategies and policy interventions. Our aim was to measure and compare changes in forest cover in pre-logging prohibition (1973-1993) and post-logging prohibition (1993-2013) periods in district Chitral. Land use map analysis showed, that despite complete ban on green felling, forest conversion to other land use types continue at high rate in the study area. Although, logging ban is partially effective in controlling deforestation as pre-ban changes in forest cover are more than the post-ban changes. However, considering logging prohibition as "one strategy fit all" will never succeed as deforestation is caused by many factors. Results of the socio-economic survey and expert interviews indicated population pressure, extreme poverty, high dependency on forest for fuel wood and timber, overgrazing, defective forest management and overlapping property rights were the main driving forces for agriculture expansion and deforestation in the area.
The design and implementation of conservation policy or combination of policies are neither simple nor straightforward, given the socio-economic, political, administrative and environmental complexity existed in the study area. For better forest protection appropriate conservation policies with holistic approach that integrates the socio-economic, bio-ecological and institutional dimensions of the area are recommended.

Forest, consrvation, Policy, Chitral, Pakistan

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7 - Europe Inside / Outside - The export of European forest policies, objectives and architecture through

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IUFRO17-712 **Centrifugation of European legality frontiers in global timber supply chains**

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Abstract: Since late 20th century many actors with interest in the forest sector attempted to eliminate illegal timber from international supply chains. Europe has been in the forefront to enhance forest law compliance and improve forest governance, resulting in the EU FLEGT Facility, the VPA initiative, and the EU timber regulations. Countries have followed with efforts to eliminate illegal logging in their forest reserves, or to stop it from entering national timber markets. There has been little international coordination to address illegal timber, except for three Ministerial conferences, and keeping illegal timber on the agenda of international organizations. Individual countries and the EU have designed policies and tools unilaterally and compliance is organized bilaterally, resulting in some success of eliminating illegal timber from supply chains, but also in shifting illegal timber frontiers. The shift of these frontiers can be attributed to the lack of coordination, but also to the profound differences in how rigorous and effective national policies and instruments to address illegal timber are. We will demonstrate this by analyzing two cases of shifting legality frontiers and link this to national efforts to address illegal timber of the countries involved. Our two cases are: timber that is sourced illegally in Eastern Russia by Chinese companies and sold to Japan, and the shift of sales of illegal timber logged in Peru, previously sold in the USA and to Europe, but since 2016 increasingly to China. We will analyze the two cases and link the dynamics of each to European FLEGT efforts and to the particular timber legality policies and legislation of each of the countries involved. Our analysis explains the shift in legality frontiers, but we also comment on the European and global forest legality regime, how it is developing, and what measures could be envisioned to improve coordination and effectiveness.

FLEGT, timber legality, global supply chains

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IUFRO17-3902 **Smart Mix against Tropical Illegal Logging: Towards an Integrated Approach**

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Abstract: The current academic approach towards tropical illegal logging is often fragmented. There is a disproportional large literature on the conditional payment transfer (e.g. REDD+), private certification (e.g. FSC) and binding legislation (e.g. FLEGT) in importing countries, which does not correspond to the importance of those instruments in the practice of deforestation and forest degradation in tropical countries. A significant part of the tropical timber is harvested for domestic use or export to other developing countries. Moreover, private certifications only cover a limited portion of timber trade between the North and the South. Following the seminal work on Smart Regulation (by Gunningham/Grabosky), together with a law and economic analytical approach, we suggest that a "smart mix" of a variety of policy instruments is necessary to combat illegal logging. Our paper argues that an integrated approach that not merely focuses on international trade and conditional payment transfer, but also takes into account internal drivers (domestic/South-South) of illegal logging is essential. In this paper, we sketch the extent of illegal logging, the presently employed instruments and identify the current gaps in regulation. Subsequently, we combine our theoretical approach with specific examples from Indonesia and present an integrated proposal of mixed instruments.

illegal logging, policy mix, timber production

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IUFRO17-4069 **EU FLEGT Action Plan's impacts to China's forestry trade policy**

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Abstract: EU issued FLEGT Action plan in 2003 to address trade of illegal sourced timber and timber products. China as EU's largest forestry trade partners, the annual forestry trades value reached to 10 billion EURO. China and EU started official bilateral coordination mechanism on FLEG since 2008, and work together to stop trade of illegal sourced forestry product became one of important cooperation area. related studies, information sharing and training activities has been implemented to improve Chinese stakeholder's understanding of EU FLEGT action plan, particular on FLEGT VPA process and EUTR. the paper focus on EU FLEGT action plan's impact on China's forestry trade policy development, especially how TLAS development, and Due diligence system be learned and adopted into china's forestry trade development.

EU FLEGT action plan, Forestry trade policy

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IUFRO17-3174 **Changing patterns in wood trade: the emerging EU regional market**

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Abstract: In the last decade many political and socio-economical drivers have been characterizing the European timber market. Since the global demand for timber products in emerging economies has increased, Europe has gradually diminished its leading role on the international timber market. At the same time, the legal requirements for placing timber in the EU market have become stricter trough the implementation of the Regulations (EU) 2173/2005 and 995/2010.
Our study aims to demonstrate that, due to these (and other) driving forces, the EU timber market is subjected to a regionalization process, with a growing concentration of trade flows among European countries. To test this hypothesis the research analyses the EU roundwood and sawnwood markets, trying to identify their most recent trends. Starting from 2005-2014 UN Comtrade data, the research aims to assess the level of regionalization of the EU timber market, through trade-related indicators such as changes in the number of trading partners for selected EU countries and the trends in extra-EU timber imports.
Results show how, after the economic crisis (2008), the role of the intra-EU trade in roundwood and sawnwood has suddenly risen, while imports of tropical timber dropped. In 2012-2014, although less evident, these trends continued.

regionalization, timber, trade, intra-EU, FLEGT

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IUFRO17-2016 **Restoring Government Forest Policy Prerogative? The EU FLEGT Ambivalent Relationship with Private Rulemaking in the Congolese Case**

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Abstract: The aim of our presentation is to critically explore the FLEGT VPAs implementation. VPAs can be seen as an endeavour of both the beneficiaries' governments and the EU to restore the prerogatives of the public authorities regarding the control of legality. By seeking certification of all the country's production of timber, successful VPAs would question the added value of independent certification schemes, such as the FSC. However, the VPA success is far from being achieved.
We especially seek to analyse the private actors and experts role. We argue here that the FLEGT has lead to an ambivalent relationship with private rulemaking and expertise.
First, the EU policy transfer towards developing states occurs in a sector dominated by private rules. NGOs, firms, experts have a contentious relationship with the EU authorities as they attempt to curve EU FLEGT policy objectives regarding their own technical norms and sustainability definition.
Second, experts are omnipresent. The EU and VPA state simultaneously mandate them to implement and to monitor the FLEGT VPA as the same expert already define technical norms that ground forest certification schemes.
Third, the national administrations have proved unable to set a reliable national system of legal verification and traceability (SVLT) and are considering endorsing private system implemented by forest companies for EUTR compliance as "equivalent" to national norms.
Grounded on a qualitative methodology, interviews with EU, Congolese and transnational organization representatives and research fields in Congo, we first analyse the EU policy transfers and then we seek to analyse the changing relationship with private actors. What are we learning from this new relationship between EU and transnational rule and how can we study it in multiscalar governance?

FLEGT VPA certification schemes authority experts

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IUFRO17-2727 **Developing a National Forest Policy in New Zealand - European Influences**

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Abstract: New Zealand has long lacked a national forest policy. This is understandable in a political environment with a strong neo-liberal, market-based leaning, where "the market will decide" has been the overriding mantra to the forest sector. Forest sector professionals, including the New Zealand Institute of Forestry have recently drafted a national forest policy to be able to deliver greater overall net benefits to the country. Accounting for the unique New Zealand context, it was developed following Australian and European models, particularly Finnish and Irish forest policies, and the new EU Forest Strategy. Despite these policies being situated in a more government interventionist context, the ideas of improving production, environmental and social outcomes through a forest policy is common to all. In its development, the sector has taken a holistic approach, including sustainable forest management, wood processing, non-timber values and uses in order to demonstrate widespread appeal and support amongst the forest and adjacent sectors. In examining the European influences on this policy development under New Zealand conditions, we also question whether a market-driven philosophy is compatible with a forest policy, given the poorly recognised time scale and benefits of forestry.

Forest policy, European influence, market-based

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IUFRO17-459 **Transitioning to a forest-based Bioeconomy? Lessons from Germany and Scandinavia**

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Abstract: Bioeconomy can be counted among recent emerging macro-political concepts defining entire science and technology policies in Western countries and beyond. Different political organizations and numerous countries worldwide have embraced it. Most national bioeconomy strategies reveal the dominant focus on economic competitiveness and stress the need for technological advancement. The role of forests and the forestry sector in the political bioeconomy is central in Scandinavian (i.e., Finland and Sweden) and western European (i.e., Germany) countries that have high-quality R&D, mature forest-based industries and abundant lignocellulosic biomass resources. Although a series of direct and indirect, bioeconomy-related policies exist at the time, these lack harmonization and are often symbolic. Further insights into how bioeconomy materialises as a driving force in forest policy and management in Europe are still missing. We postulate that these developments would play out differently in the different regions of Europe i.e., acceptance of bioeconomy, technology innovations and actor networks might look different in Sweden and Finland than in Germany. This may result in different national bioeconomy configurations with different implications for the forest sector and its stakeholders. This presentation discusses some of the most recent bioeconomy developments in Germany and Scandinavia as well as some main findings from my on-going PhD project. A mix a different theoretical insights (e.g., discourse analysis, technological transitions, social capital and intuitional changes) as well as different empirical tools (e.g., stakeholder and actor network analysis) are presented and discussed. To this end, a discussion about the prospects of a truly European sustainable forest-bioeconomy is provided.

Bioeconomy; Germany; Scandinavia

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IUFRO17-954 **25 years of C&I for SFM - Did they make a difference?**

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Abstract: Since the Earth Summit held in Rio de Janeiro in 1992, the use of criteria and indicator frameworks as a tool for systematic and continuous data collection, monitoring, evaluating and international reporting of sustainable forest management metrics has been introduced for forests in all regions of the World by various international processes. In the subsequent 10 years about 150 countries participated in eleven regional and international forest related indicator processes. However, the initial enthusiasm for these efforts lasted only a few years and the level of implementation differs considerably across countries and regions. In the past decade only a few processes have made substantial progress in the development and application of related indicators. Indicators for Sustainable Forest Management are again attracting increasing attention. In the light of major global problems and/or emerging challenges such as climate change, the continuing loss of biodiversity, deforestation and desertification or the need for a stable provision of renewable energy, the identification of adequate indicators to generate knowledge about the status quo and measure changes towards sustainable development goals becomes increasingly important. Against this background, this paper assesses the genesis and use of indicator frameworks developed by various forest related indicator processes with particular regard to their usage, achievements and impacts on SFM, their relationships with various criteria or thematic elements of SFM, relevant and emerging SFM issues, improvements/revisions or continued use for monitoring, reporting and assessment. Factors for failure and success of the processes are identified. The focus of the paper lies thus on the analysis of the indicator development and its use and impacts on SFM and gives also an outlook on changing needs, key challenges and trends in using indicators to stimulate C&I processes to maintain or regain momentum and maintain flexibility.

Indicators criteria, sustainable forest management

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IUFRO17-3416 **Forest sustainability indicators in the new light of a bioeconomy**

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Abstract: Bioeconomy is one of the guiding principles of the European Union, and is expected to generate ample opportunities for the forest-based sectors. To maintain such developments sustainable, sustainability indicators are the tools of choice. This study provides insights into the potential use of forest-sector based indicator sets in Europe for further use in a bioeconomy context. It builds on the rich experience gained with sectoral indicator tools, and connects to aspects of policy research, operational research and sustainability science.
Against this background, we analysed in a first step more than 200 indicators that are related to measuring sustainability aspects of a bioeconomy with regards to their data availability, typology, and applicability.
In a second step we develop three different scenarios for as to how forest-related bioeconomy indicators can be designed in the future. Scenario 1 describes a continuous development of forestry indicators towards achieving a stronger bioeconomy focus. Scenario 2 explores a modular indicator concept that allows for thematic and/or sectoral subsets that are flexible for adaptation. Scenario 3 introduces the concepts of key or headline indicators that track the sustainable development of a bioeconomy on a cross-sectoral basis employing a few but consistent variables. Those options are not mutually exclusive, but can be employed in a temporal sequence. They are further discussed with regards to their potential practical and political implications.

bioeconomy indicators, sustainable development

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IUFRO17-1160 **Requirements for appropriate sustainability indication**

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Abstract: What do indicators indicate? Most often, quantitative indicators simply represent numerically measurable statistical data, mainly based on a country's national forest inventory or other statistical sources. The application of these indicators typically excludes additional analysis and is thus based on just a hope that these statistics are meaningful. However, there is no guarantee that the information that these indicators are able to provide matches the information that is required for the intended use. Readily available forest statistics may indicate a status or a level; however, they alone are not informative as to whether a particular status or level is what we desire, and whether what we desire is really what is sustainable in the long term. In a similar fashion, a data series may indicate a trend, however, more information needed to assess a trend against a policy that is assumed to necessary for sustainability. To see whether such a policy really leads to sustainability, even more, and more elaborated, information may be needed, but also the capacity to interpret historical data and potential courses of action in terms of dynamics of complex systems, i.e., forests and forestry. This in turn requires a higher level of understanding of these systems. In lack of such additional information and understanding, it must be assumed that using some of the so called sustainability indicators may involve adverse consequences of false hopes. To avoid them, and to develop more correct and more useful sustainability indicators, it seems necessary to re-evaluate at least some of the currently used indicators, as well as to apply a design process to re-design them, if necessary, and develop new ones. Such a process would require the thorough analysis of both resource uses and that of related systems. The presentation will demonstrate examples of the incapability of some indicators to indicate sustainability, and some required elements of the above design process.

system, dynamics, forest, forestry, statistics

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IUFRO17-2905 **Forest related indicators to assess sustainability impacts of policy options on the Greek forests**

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Abstract: Assessing and integrating the environmental, socioeconomic and institutional impacts of forest management policy alternatives at suitable spatial scales and levels of aggregation constitutes a challenge of any forest management sustainability assessment and monitoring process. This paper presents the impact evaluation process that was recently implemented for the forest areas of Greece to assess the sustainability performance of different forest management policies, including the "business as usual" option as a baseline condition. The sustainability assessment process was conducted through the function of a recently established National Forest Governance Council (NFGC) and it included a 10 year planning horizon. Six to eight alternatives were formulated for the forest areas of each of the 13 administrative Regions of the country. Relevant at the landscape system level environmental, socio-economic and institutional indicators were selected by the NFGC members from the INFORM indicator knowledge base for sustainable forest policy and management. The Overall Forest Sustainability Performance Index of each forest management policy option was calculated through a combined fuzzy AHP multi- criteria model. According to the results the best sustainability performance could be achieved through the options focusing on i) the improvement of the wood production process (in 5 out of the 13 administrative Regions of the country), ii) forest protection from abiotic factors (in 4 Regions), iii) conservation of biodiversity (in 2 Regions), iv) improvement of water quantity and quality (in one Region) and v) forest recreation and ecotourism (in one Region). The sustainability performance rates of these policy options are expected to be 3 to 4 times higher in comparison to the current levels expressed through the baseline option.

sustainability performance, forest indicators

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IUFRO17-188 **The Austrian Forest Biodiversity Index - Concepts and Results**

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Abstract: Indicators are needed to monitor forest biodiversity. A single aggregated measure - the Austrian Forest Biodiversity Index (AFBI)- is described which is based on different indicators being weighted depending on their significance for the maintenance of forest species richness and genetic diversity. It consists of eight state, one pressure and four response indicators. Selection of state indicators is based on the general hypothesis that forests which mimic natural conditions or are characterized by structural elements of old-growth forests maintain a high number of forest dependent species and a high genetic richness therein. Impact by game and lifestock is taken as response indicator into account. Among the response indicators we consider the establishment of natural forest reserves, genetic reserve forests, seed stands and seed orchards as relevant. For each single indicator a reference value (not identical with a political target value) has been identified so that the actual indicator can be rescaled and be given a standardized score. Single indicators have been weighted based on a web-based expert consultation. The AFBI equals the weighted mean of all single indicators scores making this index simple to communicate. Overall, the AFBI indicated high forest biodiversity within Austria, however varies among ecoregions.

monitoring, conservation

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IUFRO17-3942 **Including forest certification indicators in promoting and monitoring implementation of the Sustainable Development Goals**

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Abstract: The UN General Assembly in September 2015 agreed on 17 Sustainable Development Goals (SDGs) and introduced 169 targets formulated through a cross-sectoral approach. They are aimed at guiding and measuring progress towards sustainable development until 2030.
Sustainable Forest Management (SFM), indicator for SDG Target 15.2 proved to be a complicated issue for the Inter-agency and Expert Group (IAEG-SDGs). As complex concept SFM cannot be reduced to single environmental, social or economic issues. Experts tend to use sets of multiple indicators. This is scientifically correct, but difficult to monitor and to communicate to governments, business and civil society. IAEG-SDGs therefore decided for a small set of indicators. Certification brings concrete evidence for SFM at FMU level, and speaks to business and civil society. However, inclusion of 'Forest Certification' as one of the indicators is controversial, as some government representatives and researchers hesitate to accept 'certification' as relevant indicator in this context.
We report about the outcome of the CPF discussion on "Certification" as SFM indicator; and analyze opportunities, challenges and the role forest certification schemes can play on the implementation of SFM, halting deforestation, and increasing restoration, afforestation and reforestation globally in the context the 2030 Agenda for Sustainable Development.

certification, SDG, SFM

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IUFRO17-2940 **Another brick in the Great Green Wall? Criteria and Indicators to monitor Forest and Landscape Restoration in Burkina Faso**

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Abstract: The Great Green Wall concept developed in the early 1960s aimed to i) raise awareness on arid land developments, ii) enhance local best practices in environmental management and sustainable development, iii) implement integrated approaches to sustain livelihoods in Sahelo-Saharan regions of Africa, and iv) find long-term solutions to combat land degradation and drought impacts. In 2007 the pan-African program Great Green Wall for the Sahara and the Sahel was launched to reverse land degradation and desertification, boost food security and support local communities to adapt to climate change. But not only in Africa are restoration efforts gaining political priority over the last decades. The adopted goals of the Rio conventions identified the need to restore the productive capacity of degraded and deforested lands as well. In turn, the concept of forest and landscape restoration (FLR) emerged as a powerful participatory decision-making process at global level supporting the achievement of these targets. FLR strives to identify, negotiate and implement practices that help to restore an agreed optimal level of ecological, social and economic benefits of forests and trees within a broader pattern of land uses. Consequently in 2011 IUCN and the Government of Germany established the Bonn Challenge with the aim to restore 150 million hectares of the world's degraded land by 2020. In this study we test a suite of existing criteria and indicators for their applicability to evaluate FLR efforts. We develop a framework to monitor FLR progress and demonstrate its application in selected restoration projects in Burkina Faso. Bridging a multitude of factors at various spatial (e.g. mosaic, landscape) and temporal (e.g. short-, mid-, long-term) scales we provide a tool to assess and monitor diverse ecological and economic parameters in order to measure progress towards FLR and report about the state of landscape degradation (e.g. productivity, biological diversity).

degradation, restoration, sustainable development

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IUFRO17-3450 **"Indicators - a task for citizen's science?**

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Abstract: The question of a sound indicator development process has been studied earlier. In general, a bi-polarity can be observed between science-driven and policy-driven indicator processes. They can both be driven by bureaucrats involved in a specific area, as well as include policy-makers, scientists and citizens. Citizens and stakeholders usually participate only at a very limited rate or remain not involved at all. Following the normative aspect underlying the sustainability concept, participation is however strongly connected to the idea of democratic practice.
The indicator literature highlights the need to better understand and structure the development process as such. Some authors have outlined more technical approaches to sustainability indicator development to be followed; others have pointed out that the participation aspect is crucial for the norm creation and knowledge production process that both underlie the development of sustainability indicators. This means that the definition of sustainability indicators becomes more a political and/ or social challenge rather than a technical-scientific problem. This incorporates strong emphasis on participation and transparency both within the development process and its implementation. The involvement of concerned citizens or lay persons into sustainability indicator processes to our mind has not been a main topic in sustainability indicator research so far and thus needs more attention.
We assume that the opening up of such processes to citizens and lay persons does not only increase legitimacy and accuracy of indicators, but also enhances public awareness for the sustainability topic. The proposed research paper aims at improving the sustainability indicator selection, definition and evaluation through the involvement of lay persons and concerned citizen. Data were collected in an experimental setting simulating a forest sustainability indicator process during two research seminars designed for students.

sustainable forest management, participation

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KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1799 **Bioecionomy- the political framework**

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Abstract: More and more countries in Europe including the European Union have developed or are currently developing bioeconomy strategies. Ten years ago the very same countries did not give a lot of credit to the same concept. While some countries like Finland and Germany nowadays put a lot of political weight into the development of those strategies, others like Austria have not directly started the development of such a political document. Those strategies are seen as means to tackle main societal challenges, as well as to create opportunities to reconnect economic, social and environmental goals. Bioeconomy strategies are however not formulated in a neutral policy space. On the contrary a lot of policies including a large number of policy instruments that address supporting and contradictory policy objectives are pre-existent.

The current paper assesses on the one side the current policy framework in place in the European Union and pan-Europe in relation to forests; on the other side it takes stock of bioeconomy strategies in Europe and analyses as to how those relate to forests.

Bioeconomy, bioeconomy strategies, forest policies

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IUFRO17-3140 **The environmental dimension of a European forest based bio-economy**

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Abstract: European forests and the forest-based sector play significant roles in two different, equally important policy contexts. First, over several decades, they have been a major actor in mitigating climate change, compensating more than 10% of EU GHG emissions annually. We argue, that climate smart forestry measures could even enhance the role of forests and forest product use in climate change mitigation. Second, the forest-based sector is also playing a crucial role to develop the European bio-economy.
This presentation reviews how new management strategies and technological developments in processing and researching new fuels and products will contribute to the above policy targets and to what extent these strategies and technologies support each other. Relatively little attention is paid to the sustainability of the whole sector in the future and whether the forest environmental and resource part of the chain can keep up with the fast developments. This 'environmental dimension' needs attention, otherwise the wood based bio-economy will not last long. Exemplary conflict domains include environmental concerns around pellet imports from the SE of the USA and signals of illegal logging in Romania. However, so far harvesting pressure on European forests has not increased.
In the presentation we will address the environmental dimension from recent signals of management trends and harvesting pressure, review the effects of alternative climate change mitigation strategies on carbon sinks in forests and soils, harvested wood products and fossil fuel substitution, and evaluate evidence related to impacts of alternative strategies on the nutrient balance, and biodiversity trends. Further, we will project the degree to which forest management can follow an increased demand and how various functions of the forest (e.g. GDP and carbon) could be met in synergy. We will a European perspective, but also focus on case regions on aspects of wood mobilisation.

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IUFRO17-3998 **The social dimension of a sustainable European forest based bioeconomy**

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Abstract: A future European forest based bioeconomy has many facets, with social aspects being a core issue. In this presentation we approach the "social dimension" of a forest based bioeconomy in Europe. Our starting point is the assumption that a future forest based bioeconomy will need to create values related to a broad spectrum of forest ecosystem services, in response to a broad and diversifying spectrum of societal values. We explore this assumption based on collaborative work of a larger set of scientists from distinct disciplines with regard to three main issues. Firstly, we take the case of the valorization of cultural ecosystem services as exemplified by nature-based tourism and show that this steadily growing business may create significant opportunities for forest owners and users in the future to diversify their income, but may also result in conflicts with other forest uses. Secondly, we focus on the economic and social importance of non-wood and wild forest products as an example for an often underestimated value chain arising from Europe's forests that holds significant potential for rural development and innovations between rural producers and urban consumers. Thirdly, we investigate the development of jobs and employment in the future forest bioeconomy, and explore the transformation of labor in this field. We conclude by putting these exemplary findings in a broader context of societal relations with forests in Europe, that we believe are directly relevant for working towards a forest based bioeconomy that is not only competitive and environmentally sustainable, but also socially inclusive.

bioeconomy, social, society

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IUFRO17-511 **Economic sustainability in European forest bioeconomy: prospects and challenges?**

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Abstract: From an economic point of view, a sustainable forest bioeconomy must encompass both a tangible component associated with bio-resources and an intangible component in terms of an ability to produce and process knowledge and to innovate. These ensure adaptation in the changing global economic forces and coping with inherent sustainability challenges. But what is Europe's real capacity to innovate under the current market and economic situation? We analyze product and business model level prospects for strategic diversification in the European forest bioeconomy by reviewing relevant literature and industry examples. We conclude that the economic competitiveness of the forest-based bioeconomy is, in the long run, increasingly dependent on the industry leadership capability and the contribution for societal transition towards sustainability. Furthermore, the strategic measures targeting higher value-added products and services must be better able to contribute to customer satisfaction and enhance relative competitiveness over non-European rivals. Empirical research is also called for to fully understand the scalability and market potential of new forest-based bioproducts and services. Finally, an important aspect is how industry cross-sectoral collaboration can be strengthened.

bioeconomy, competitive advantage, Europe

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IUFRO17-1273 **Outlook for forest-based bioeconomy in Europe**

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Abstract: The presentation focuses on the outlook of forest-based bioeconomy in the Europe. The discussion takes a long-run perspective, with the emphasis on structural issues rather than on business cycles. It mainly addresses bioeconomy products and their markets, but also raises the importance of services. It analyses how recent, ongoing and anticipated future changes, will create both opportunities and challenge for the forest-based sector. The approach taken emphazies the perspective that, although the development of forests, the functioning of forest ecosystems and supply of wood is important, nevertheless the major driving forces changing the sector in the coming decade comes from the demand side (use of forests and wood), and outside the sector itself. Also, in the forest research, the market and demand analysis has been lacking, and needs more attention. Finally, the review concludes with the implications of the ongoing changes to the methods and research on the topic.

outlook, bioeconomy, Europe, markets, methods

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26 - Policy learning across governance levels for durable results

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IUFRO17-2775 **Towards durable solutions in sustainable forest management: A reflexive overview on the pilot application of a policy learning protocol to legality verification and community rights in Peru**

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Abstract: This paper reflects on the insights and key lessons that emerge from the design and pilot application of an 11-step policy learning protocol developed by the IUFRO Working Party on Forest Policy Learning Architectures. The protocol provides a conceptual toolkit based on Cashore and Bernstein's four pathways of influence framework that actors may use when working with international environmental policy processes in order to promote more durable policy solutions for a broad range of sustainable development issues. In the first implementation of the protocol in Peru in 2015 and 2016 we focused on global timber legality verification policies and how they can be harnessed to promote local land rights, including titling. Working with key stakeholders we identified a specific problem definition salient to forest communities, namely: "How can community legal access of, and access to, forestland and forest resources be enhanced?" As members of the project team we use this paper to stand back and critically evaluate our work, how the process of designing and working with the protocol has changed our thinking, and what this suggests for a new approach to policy implementation that seeks to work creatively with existing international policy instruments. The protocol has been designed as a dynamic and evolving tool, implementation of which should be approached as an iterative rather than a linear process; that is, when working with the protocol completion of one of the eleven steps may require revisiting an earlier step. The protocol can be used by stakeholders operating at any level of governance to understand better the causal processes through which global governance initiatives might be harnessed to produce durable results on the ground.

community rights, durability, illegal logging

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IUFRO17-673 **Moving beyond forest governance in silos in the Democratic Republic of Congo**

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Abstract: Multi-level governance (MLG) of forest resources involves complex interactions of state, private and civil society actors at various levels, and institutions linking higher levels of social and political organization. Local communities are increasingly connected to global networks and influences. The number of non-state actors behaving like states has grown. This creates opportunities to learn and address problems but may also introduce new pressures and risks. There is need for a much more complex approach to the varieties of MLG to better understand how policies work as instruments of governance and to organize communities within systems of power and authority.

Current sectorial approaches to land and resource management in DRC are inadequate to address complex challenges such as poverty alleviation, food and energy security and climate change particularly in a context distinguished by a lack of, or decline in the regulatory leverage of the state, the growing 'commodification' of nature and renewed faith in globalized trade, Multilateral Environmental Agreements and neoliberal capitalism. Critically, there is little capacity to build capacities and an ageing civil service. Recent (renewed) interest in integrated landscape approaches is suggested as one way to manage trade-offs and balance competing demands to achieve sustainable land and resource use.

The paper asks the question "Can a landscape approach help us move beyond governing in 'policy silos'?" by comparing and contrasting the strengths and weaknesses of domestic governance reforms, and external approaches adopted under i.a. CITES, Forest Stewardship Council, FLEGT, REDD+ and EITI frameworks in the Democratic Republic of Congo over the past fifty years. It concludes with a summarized overview of CIFOR's strategy to improve governance by building capacity in DRC. The article stresses the importance of historical perspectives in understanding changing patterns of governance.

DRC; governance; CITES; FSC; FLEGT; REDD+; EITI;

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IUFRO17-1392 **Policy learning through access to information - a case study of non-state regulatory authority and transparency through REDD+ and FLEGT/VPA implementation in Cameroon**

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Abstract: As technological advancements in forest monitoring allow for the generation and analysis of increasingly large datasets, forest policy makers and practitioners are looking for innovative yet practical ways for information transparency to transform forest governance. This is especially relevant in tropical forest countries where climate finance commitments and timber trade agreements aim to address deforestation and forest degradation, which is increasing in many contexts. Cameroon serves as a relevant case study because its civil society has long fought for legal decrees that clearly outline the Government's procedures for duly disclosing public environmental information. With efforts unavailing, the access to information agenda has been placed at the fore of both the Reducing Emissions from Deforestation and forest Degradation (REDD+) process and the Forest Law Enforcement, Governance and Trade (FLEGT) Voluntary Partner-ship Agreement (VPA). Cameroon's plans for REDD+ include community monitoring, safe-guard information systems (SIS), and compliance with the recently developed Free, Prior and Informed Consent (FPIC) guidelines for REDD+. The country's VPA is highly regarded for be-ing the first to include a transparency clause in its Annex, where the government outlines its commitment to render public relevant forest information. As Cameroon moves for-ward with policy implementation, it remains unclear what information should be rendered to which actors and more importantly, how this transparency will induce learning, and change. This empirical study will apply policy learning concepts to better understand whether and how information transparency may affect non-state actors' ability to exercise regulatory authority. Finally, the authors discuss the implication of these findings on other tropical forest countries where similar transparency agendas through transnational forest policy initiatives such as REDD+ and FLEGT/VPA are underway.

Information transparency, forest governance

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IUFRO17-4098 **Seducing the already seduced? The potential of soft-governance instruments and processes for making the forestry sector more competitive through gender equality**

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Abstract: The forestry sector has traditionally been a male workplace which has promoted research on forestry work and entrepreneurship not paying attention to the role of gender. In recent years an increasing number of women have become active in the forestry sector and women have begun to be recognized in their roles as forest owners and entrepreneurs. However, the forest sector is still one of the most gender-segregated in Sweden and has not followed the wider move in other businesses sectors towards greater gender equality. To facilitate a more equal and competitive forestry sector and sustainable rural development, the Ministry for Rural Affairs has launched a National Gender Equality Strategy (NGES) for the forestry sector. This governance-oriented strategy provides an important incentive for the sector to begin a comprehensive effort of development and change, but does not describe other means than knowledge transfer and information by which the objectives are to be met.

The paper discusses the potential for soft-governance instruments and processes such as the NGES to implement a strategy aiming at improved competitiveness through gender equality. The underlying social and behavioral science question it thus whether it is possible to lead the target group to actions, behaviors, and even identities in line with the objectives of the NGES using only the soft-governance models inherent in these documents?

The literature review and policy analysis upon which the paper is based shows how policy programs designed to support rural business often have been carried out in a top-down fashion without sufficient knowledge about specific target groups (i.e. women) in specific places, and have primarily focused on men's businesses within the primary business areas. Therefore specific support built from the grassroots level with sufficient knowledge about the target group, is crucial for facilitating a more gender equal entrepreneurial identity for women within the forestry sector.

policy programs, governance, women entrepreneurs

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KG I - 1228 (Uni Freiburg)

IUFRO17-1893 **Do policy actors learn through forward-thinking? Conflict and cooperation relating to sustainable forest management in Germany**

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Abstract: Recently, a main argument has been put forward that foresight-based participatory processes will help achieve sustainability in natural resource management. In result of policy learning based on long- and short-term future-oriented thinking and actions, policy actors are expected to overcome their conflicts through informed communication, deliberation, and mutual cooperation. This should result in integration of competing societal demands on forest land use (e.g., timber production, nature protection, recreation). But do policy actors learn when they are thinking, debating and shaping the 'forest futures' they want to achieve or avoid? To what extent are (pre-)existing beliefs, values, and interests at stake projected onto the future? What are their impacts on policy learning today?
The paper addresses these research questions from the knowledge-based perspective of policy learning theories. The paper presents empirical results from three case studies of 'forest futures' processes in Germany. The paper is based on a qualitative analysis of interviews and documents about past and future forest land uses, and observation of participatory scenario-building and back-casting workshops during 2011-2014. In particular, changes and stability in actors' beliefs and behavior were traced. It was found that forest policy actors adhered to their pre-existing beliefs. Actors remained divided about sustainable forest management. While no substantial policy learning was observed, strategic learning was often found to be at play. We explain these findings by competing actors' core beliefs that led to different understandings and expectations of 'sustainable forest futures'. We discuss our research findings against the state of the art and theoretical propositions about policy learning. We draw conclusions relevant for scholars and policymakers interested in collaborative policy learning processes, and suggest possible topics for further research.

beliefs, forest futures, landscapes, learning

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IUFRO17-2720 **Venue shopping or policy learning? Chinese enterprises' responses to international legality requirements**

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Abstract: The emergence of transnational approaches to combat illegal logging and related trade, such as the US Lacey Act amendment and the European Timber Regulation, has spurred much debate. Scholars ask whether the new legality requirements will undermine forest certification, lead to lower versus higher global standards, and/or contribute to ineffective fragmentation and venue shopping versus productive policy learning. It is commonly acknowledged that the effectiveness of any transnational regime to combat illegal logging and promote sustainable forestry depends on the incorporation of China as a major player. In the debate focus is on the Chinese State's response to the emerging approaches and less on the Chinese enterprises. This is problematic since Chinese enterprises have a range of independent response options. Based on primary data from a questionnaire distributed to 500 Chinese wood-based companies we address this research gap by investigating to what extend the Chinese enterprises are aware of the legality requirements, what options they have, what actions they have taken, and what challenges they experience in relation to meeting the legality requirements. Finally, we discuss whether the responses can be interpreted as venue shopping or policy learning, and what the implications are for the timber legality regime.

China "timber legality" "private sector"

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IUFRO17-3382 **Setting up a Durable Policy: Challenges and Opportunities for China's Forestry Trade Policy**

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Abstract: Global trade of forest products by value reached USD 492 billion in 2015 and 10% of it is estimated to have come from illegal logging by report issued by Chatham House in 2015. The trade of forest products from illegal and unstainable sources remains a key factor in global forest deforestation and degradation. The governments of developed markets (e.g. U.S., EU, and Australia.) have put in place requirements which prohibit timber product imports from illegal sources. Some large timber-exporting countries have also strengthened forest laws and their enforcement. China, the linchpin in the global forest product supply chain, has signaled its growing support for sustainable timber trade through voluntary government guidelines, green public procurement and credit policies, and started to pilot Chinese timber legality verification system in 2015. Chinese forestry authority is also planning to develop more direct forestry trade management regulation to excluded importation of illegal sourced forestry products. The paper aims at synthesizing and evaluating China's forestry trade policy development and implementation from "durable policy" angle. It focuses on pathways and results of China's forestry trade policy in past 40 years (1975-2015), and lessons learned on forestry trade policy globally. The paper starts with a broad overview of China's forestry trade policy in past 40 years. It then outlines the Chinese forestry trade policies development pathways in the different stage, exams key policies implementing results, and the durability in past 40 years. Finally, it seeks to identify global lesson learned and policy making and learning gaps China faced on forestry trade policy.

Forestry Trade Policy, Durable results

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IUFRO17-1795 **The impact of increased EU bioenergy demand on the use of woody biomass for material and energy**

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Abstract: EU has proposed ambitious targets for greenhouse gas emissions reductions by 2050. A large part of the emissions reductions is expected to be attributed to replacement of fossil fuels by renewable energy sources, in which bioenergy plays a major role. In this study, we investigate the impacts of different scenarios for EU bioenergy demand using a global partial equilibrium model GLOBIOM. The study results highlight the importance of considering the full flow of wood in the analysis: as bioenergy demand increases, forest industry by-products become more valuable and enhance the profitability of the main product as well. This is especially evident for sawmill industries, which can increase their material production while they also provide a substantial share of bioenergy feedstock; on the contrary, industries using by-products for material production, such as fiber- and particleboard producers, face an increasing competition on their feedstock. Through these results, this study shows that considering the wood flows within the industries are essential in evaluating the future challenges and possibilities that climate change mitigation efforts entail, both within the forest sector as well as the whole land use sector.

EU bioenergy policy, wood flows, forest industries

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IUFRO17-465 **Climate change mitigation challenge for wood utilization - the case of Finland**

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Abstract: The urgent need to mitigate climate change creates both opportunities and challenges for forest biomass utilization: it provides substitutes for alternative materials and fossil energy, but reduces forest carbon stocks due to wood harvesting. We assessed the life cycle carbon balance of constant wood utilization scenarios over upcoming 100 years in Finland, considering various structures of forest industry and avoided emissions through substitution of alternative products. Parameter uncertainties and sensitivities were explored using stochastic simulation. The results show that wood utilization may increase or decrease the overall net carbon emissions. However, significant decrease in net carbon emissions is very or exceptionally unlikely. Most of the uncertainty is due to assumptions regarding the influence of wood harvesting on forest carbon stocks and avoided emissions through substitution for alternative construction materials. Managed forests are an important source of renewable materials and energy deeply required by society, but our results imply that the trade-off between the avoided emissions through substitution and forest carbon sink means that wood utilization is not an effective measure for acute climate change mitigation. We discuss the prospects of improving the climatic impact of the forest sector.

Life-cycle analysis, forest sector, climate change

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IUFRO17-3096 **Social sustainability and multiple-use of forests in Finnish bioeconomy**

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Abstract: This paper argues that social sustainability is a key issue and a source of concern for the transition towards forest-based bioeconomy, specifically when intense natural resource management practices are applied. The Finnish Bioeconomy Strategy aims at considerable increase in logging and forest biomass use. Our guiding thought is that, social sustainability is the spearhead for economic and environmental sustainability. Despite of the sustainability goals of both Finnish and EU-bioeconomy strategies, the sustainable development vision and the actual implementation may have substantial differences. Transition to bioeconomy is not automatically sustainable development. Our study focuses on forest-based bioeconomy discourses and especially to their underlying social patterns of sustainability relating to the positioning of actors, and to narratives about interests and values. It aims to support responsive multi-actor governance. This paper emphasizes the importance of multiple use of forests in the context of bioeconomy. Social sustainability calls for more equitable strategies for satisfying the demands from multiple forest actors. Our aim is to understand what kind of demands for instance, in terms of natural resources, and participation in decision-making processes, do these actors have. Is forest-based bioeconomy a new challenge for the interaction between these actors?

social sustainability, forest-based bioeconomy

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IUFRO17-3934 **Assumptions on forest owner behavior and their implications for ecosystem service provisioning**

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Abstract: European forests are expected to provide a broad range of ecosystem services (ES). This capacity is however threatened by the uncertainties of climate change and the pressures for increased use of bioenergy. Such challenges cannot be effectively addressed without, firstly, good knowledge of the long term provision of ES under different management regimes and, secondly, understanding how forest owners will act under different conditions. The Horizon 2020 project ALTERFOR is investigating the viability of new forest management in 10 landscapes throughout Europe. One case is situated in Southern Sweden, comprising some 600,000 ha with about 15,000 forest owners. The purpose of this presentation is to show the implications of different assumptions concerning forest owner behavior. Three approaches are tested; that all forest owners are profit maximizers, that all forest owners are harvesting as given by the National Forest Inventory data, and one where the individual forest estates are identified and assigned management preferences based on survey data and interviews. The two former approaches treats forest owners as a collective, governed by an averaged response function, whereas the latter attempts a micro simulation of the basic forest decision units. The different sets of assumptions are simulated for a 100 year period with the Heureka simulator under 2 market scenarios, one with current prices prevailing and one with prices assuming increased bioenergy consumption. The outcome is examined regarding the apparent "realism" of the respective approach, i.e. do the harvest pattern over time in some way seem logical and in agreement with past behavior. Another aspect at focus is the implications for policy analysis. It will be argued that the micro simulation approach offers other possibilities for understanding of the likely connection between policy instrument and forest management outcome than the traditional way of conducting large scale long term analysis.

policy analysis, ecosystem services

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IUFRO17-3180 **Looking at bioeconomy from different perspectives: technological and social innovation approaches**

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Abstract: Bioeconomy is getting momentum within the political/research agenda in Europe. About 20 regional, national and sub-national bioeconomy strategies have already been developed (more than 40 globally) nonetheless there is no univocal understanding of this concept.
Based on existing literature, two different approaches to innovation in bioeconomy can be identified, i.e. (1) a traditional technological-based approach and (2) an emerging social-based one. The former builds on adaptive strategy and relies on technological/organizational innovations and large-scale investments, focusing on the primary sector mainly as a raw material provider. Examples include large biomass plants and biorefineries in Northern Europe, often depending on imported rather than locally sourced inputs. The second approach considers social innovation and networking as crucial issues for cross-sectoral development and horizontal integration. Forests are seen as green infrastructures promoting rural development through the delivery of added value products and ecosystem services. Examples include public-private partnerships to promote forest management, networking for marketing of wild products (e.g. mushrooms), and the development of cultural and social services (e.g. recreation, health and well-being). The innovative dimension of these initiatives often relies on new forms of networking among different actors. The paper provides relevant examples.
Although additional research is needed to fill existing knowledge gaps, the second approach seems to better fit the Mediterranean context, characterized by fragile and fragmented forest resources, often presenting limited financial profitability while ensuring valuable public goods. From a Mediterranean perspective the innovative aspects of the bioeconomy seems to rely on equity, social inclusiveness, local knowledge and employment creation, i.e. on social more than technology innovation. However, integration among the two approaches is advisable.

bioeconomy, social innovation, Mediterranean

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35 - "Après Paris": global integration of forest climate governance

KG I - 1228 (Uni Freiburg)

IUFRO17-1954 **Concerting climate action on forests: the role of non-state actors**

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Abstract: The newly adopted Paris Agreement prominently encourages non-party stakeholder engagement - a new tone in international relations which rests in the belief that engaging actors from civil society, business, subnational authorities, indigenous peoples or academic institutions can be decisive for more effective, efficient and innovative climate action.

When coordinating, networking, initiating, authorizing, auditing, rewarding, funding, or informing, and thus substantially shaping, climate actions transnational initiatives typically work in conjunction with rather than in isolation from (international) governments (Reinecke et al., 2014). For gaining a better understanding how and when exactly such concertation of action works recent transnational climate governance efforts in the area of deforestation / forest landscapes restoration, like the Bonn Challenge, the Gold Standard or Trase are investigated to reveal the practical ways of how these settings are tied to international action and what specific roles non-state actors hold in coordinating different actors internationally. Conceptually the work draws on an own analytical typology of two-sided (informal) interaction patterns stressing the role of i) demarcation, ii) ideas, iii) actors, and iv) role models.

Reference:
Reinecke, S., Pistorius, T., Pregernig, M., 2014. UNFCCC and the REDD+ Partnership from a networked governance perspective Environmental Science and Policy. Special Issue: Forests Climate Policy, 35: 30-39

non-state actors, governance coordination

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IUFRO17-413 **Non-State Circulation in Forest and Climate Change Governance: the Case of the FLEGT-REDD+ Linkages**

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Abstract: Our submission analyzes the FLEGT-REDD+ linkages that non-state actors try to build, to draw lessons from the EU FLEGT Action Plan and apply them to the REDD+ mechanism.

Indeed, to be operant, REDD+ must lay on effective land tenure, forest policy and legality of wood production. The EU FLEGT Action Plan has precisely for aim to become such a successful mechanism. It takes the shape of Voluntary Partnership Agreements (VPAs) that specify the legal framework and responsibilities in the signatory country. Moreover, the mechanism's reliability is grounded on a participative governance process including all stakeholders from civil society at the international, national and local levels.

Following the FLEGT VPAs implementation, the EU, and various NGOs, have attempted to transfer such cooperative and participative experience to the governance of climate change and the related REDD+ mechanism. Indeed, in the mosaic of instruments and actors, civil society's role is neither clearly defined nor legally recognized. Building on the FLEGT experience was seen has an opportunity to implement its main lessons on this topic.

Grounded on a quantitative and qualitative methodology including a 4 weeks field research stay in the Republic of Congo and 3 months in Brussels to interview EU, NGO and firm representatives, we first analyze non-state mobilizations to link the FLEGT mechanism to the REDD+ at the international level, through the screening and analysis of international and European negotiations. We then analyze how both mechanisms are linked on the ground, presenting current non-state participation on both FLEGT and REDD+ initiatives in the Congo Basin and especially in the Republic of Congo.

Our contribution sheds light on learning processes at the multiple levels of policymaking on the issue of non-state participation to forests management. It exposes past practices and new perspectives for the implementation of REDD+ regarding multisectoral forest issues.

FLEGT REDD+ civil society multilevel governance

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35 - "Après Paris": global integration of forest climate governance

KG I - 1228 (Uni Freiburg)

IUFRO17-3680 **Thinking beyond the Paris conference: the importance of understanding the North-South cooperation context on climate change in the Congo Basin**

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Abstract: Reducing deforestation (REDD+) is definitely a main strategy of the fight against climate change in the Congo Basin Forests. However, beside this mitigation purpose, COMIFAC (Congo Basin Forests Commission) countries are also expressing adaptation needs which they consider complementary to REDD+ and which if not tackled might end-up wrecking the climate change fight effort. As the global North is definitely one of the major partner of the handling of adaptation issue in the Congo Basin Forest, understanding the North-South cooperation context thus become there a main challenge of the après-Paris. Hence the value of this paper that aims at providing with characteristics for a better understanding of the North-South cooperation context on climate change adaptation in the COMIFAC countries. As research object of this paper, the project "Scenarios of climate change in the Congo Basin" involving European Union's and COMIFAC's countries has been selected and a participative context assessment method based on questionnaires, interviews and personal observation has then been applied to the northern and southern stakeholders of the project to capture their deep consideration of the cooperation context. The survey's outputs have thus led to the following conclusion: the North-South cooperation context on climate change is an ambivalent and strained context marked by both fusion and mistrust between the northern and southern stakeholders. The ambivalence of this cooperation context appears as being due on one hand to the tendency of northern counterparts to exclude South from the elaboration and implementation of the climate change adaptation initiatives they are carrying in South and on the other hand to the high expectations South is putting on North on the handling of climate change issue. Carrying a pertinent North-South cooperation on Climate change adaptation in the Congo Basin Forest countries thus implies to deeply consider the ambivalence of its context.

REDD+, adaptation, COMIFAC, European Union

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IUFRO17-977 **Sustainable biofuels: Opportunities and challenges of polycentrism in global governance**

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Abstract: Regulation of biofuels exemplifies the new pathway to polycentricism in global governance. Especially, transnational business and auditing companies are ascribed new roles in policy-making and implementation. After the 2007-2008 food price crisis and growing disagreement with biofuel promotion, several multi-stakeholder initiatives formulated criteria for 'sustainable' biofuel production, for example, the Roundtable of Sustainable Palm Oil (RSPO) and the International Sustainability and Carbon Certification (ISCC). When in 2009 the European Union (EU) decided to further promote biofuels by replacing 10 percent of fossil-based transport energy with renewables by 2020, the Renewable Energy Directive (RED) made 'sustainability' certification a requirement for biomass-based transport fuels contributing to this goal. So far, the European Commission has recognized 19 private schemes. Private certification is also required for harvest and production in third countries, if biomass is later processed to fuel and exported to the EU in order to contribute to the 10 percent target. Using the example of palm oil from Indonesia, the paper/presentation discusses opportunities and challenges of the EU RED approach to re-regulate global supply chains.

European Union, biofuels, palm oil, sustainability

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IUFRO17-3960 **Greening supply chain of leather: Opportunities and challenges of involving smallholder farmers in zero deforestation economy**

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Abstract: Tackling global deforestation has been on the agenda of the international community for decades. Different policies, regulations and third party verification systems have been directed towards conserving the world's remaining forests and tackling illegal and unsustainable use. While acknowledging the role of private sector and investors in achieving a deforestation free economy, there is an increasing trend among businesses to put forward their time bound targets. However, challenges exist along the way. Among them uptake and implementation of zero deforestation commitments remain most important. Majority of companies with commitments are manufacturers and retailers located in developed countries, while those operating upstream of supply chains and in developing countries still lag behind.

Livestock sector being the largest contributor to tropical deforestation is relatively slow with commitments to deforestation free supply chains. Processing indirect but at the same time very valuable product of cattle ranching, Italian leather industry is facing a lot of pressure to tackle the issue of deforestation with their upstream smallholder suppliers in Brazil. Incomplete traceability, complexity of the upstream tier of the supply chain, and lack of negotiation power are among many challenges on the way. This study explores the direct linkage between leather industry and deforestation in Brazil by concentrating on the value chain of leather, and analyses opportunities for small scale farmers to adopt deforestation free practices. Vast literature review and application of supply chain governance theories help to identify possibilities and hurdles of adoption deforestation commitments by smallholders.

Key words: zero deforestation commitment, leather industry, supply chain, smallholders, livestock

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63 - Forests for the Health of the People

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IUFRO17-3123 **Forests, meadows or vineyards? Results of landscape effects on human health in the Wienerwald Biosphere Reserve**

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Abstract: The urban European society is faced with a growing incidence of poor health because of mental stress and sedentary lifestyles, therefore activities in green spaces are seen as a counter. It is assumed those spaces can compensate for negative psycho-physiological effects. Unfortunately, previous studies on the assessment of restorative effects of green spaces rarely compared different types of green spaces. Therefore the project HealthSpaces explored this question in the Wienerwald Biosphere Reserve (Austria), which was used as a field laboratory as it offers a scattered matrix of natural and cultural landscapes.

Standardised measurements of psycho-physiological health related landscape effects on participants (e.g. measuring of blood pressure, cognitive performance, self-condition scale) were carried out in 5 selected landscape types of the Wienerwald (forest, vineyard, pasture, small river embedded in a forest and an urban area for comparison measurements). We used a dependent sample of 44 participants who spent about 45 minutes in each of those landscape types.

The results showed that the visits in the green spaces had positive effects on the perceived well-being of the participants; the subjective stress level of the participants has been reduced and the subjective well-being has been improved during the experiment. After the visits of the green spaces, the participants felt more relaxed, calmer as well as more content. Furthermore, the cognitive performance of the participants increased after the visit of the vineyards, forests and meadows. The meadow proofed to be the most restorative environment for the probands in terms of subjective recreational effects and perceived reduction of stress. The forest was rated as the second best restorative landscape because of its high naturalness. In summary, the study showed that restorative effects differ among the landscapes and their diversity play an important role for the wellbeing of the population.

health effects, forests, cognitive performance

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IUFRO17-2993 **How can forests contribute to restoration and what kind of forest is best suited to foster restoration and wellbeing?**

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Abstract: There is a growing interest in the potential role of the natural environment in human health and well-being. The main reasons for this can be seen in the urbanization in many countries leading to a loss of natural areas for recreation. Additionally there is a rise of stress-related diseases in many countries that is caused by high workload and a sedentary lifestyle in many western industrialized countries.
In a first part of the presentation we will give detailed insight in the psychological concept of restoration that is in the center of the research on health effects of landscapes and present the most important theory on restoration originating from environmental psychology, the attention restoration theory. This theory explains how and why a landscape evoking feelings of Fascination, Being away, Coherence, Extent and Compatibility can foster the restoration process. In a next step we will present some of the methods used to assess the (level of) restoration and/or well-being of the individual, such as standardized self-report scales and physiological methods (e.g. cortisol). Additionally we will give some detailed insight into empirical evidence from different quasi-experimental studies and population surveys. As it is well proven that the natural environment is better suited to foster the well-being and restoration of the individuals than urban environments, we will go one step further and analyze the influence of different physical environments, such as wild and tended urban forests on restoration and well-being and focus on the question of the relevant forest characteristics that are associated with psychological restoration and hence are relevant for human health and well-being. The results will give important advice how to design natural areas serving restoration and public health, especially for people living in urban environments.

forest characteristics, restoration, well-being,

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IUFRO17-291 **Management effectiveness of Secondary coniferous forests on Landscape appreciation and Psychological Restorativeness**

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Abstract: We investigated the influence of forest management on landscape appreciation and the psychological restorative effect in an on-site setting by exposing respondents to an unmanaged coniferous forest (U.F.), and a managed coniferous forest (M.F.) for a particular period.
The two experimental plots (0.25 ha) were set in a university forest of the University of Tokyo as U.F. and M.F. setting. The respondents were eighteen individuals (eighteen males; aged twenties to fifties). They were individually exposed to the both settings while sitting for 15 min. In the both settings, the respondents were required to answer the three questionnaires to investigate the psychological restorative effect at before and after the experiment (mood; POMS, affect; PANAS, subjective restorativeness; ROS). For comparison of landscape appreciation, they were required to answer other two questionnaires at only after the experiment (scene appreciation (SD), a restorative property of environment (PRS)).
Consequently, negative affect, tension, and anxiety might come to decrease because the managed forest setting had a sufficient restorative property of the environment and the better scenic environment. Conclusively, respondents would obtain a psychological restorativeness to some extent by being exposed to M.F. setting.

ART,appreciation,feeling,affect,restorativeness

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63 - Forests for the Health of the People

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IUFRO17-3165 **The meaning of wilderness: emotional mapping in the Black Forest National Park**

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Abstract: Scientific evidence has shown the restorative effect of natural environments. However, only few empirical studies distinguish between different types of environment. The Black Forest National Park (founded in 2014) covers a diversity of landscapes ranging from cultural forest to wilderness, which allows for unique field-experimental research. In 2016 a study with 111 participants explores restoration effects of wilderness compared to other types of landscape experience. Participants were guided to walk through the forest encountering different types of landscapes. In a mixed method approach psychophysiological arousal and georeferential data were continuously captured. Additionally ecological momentary assessments of subjective landscape experience were collected as well as pre-post cognitive testing and subjective well-being surveying.
The results underline health benefits of wilderness experience most clearly on a psychophysiological and cognitive level. On a subjective level, the restoration effect of the various landscapes was more ambiguous. People generally perceived wilderness as fascinating and showed positive physiological arousal, but consider this in in a wide variety of ways. This points to the relevance of a mixed method approach in order to grasp the complexity of landscape health effects.

emotional mapping, wilderness, restoration

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IUFRO17-3753 **Forest related art of leisure - concepts in history and presence**

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Abstract: The health research field identifies the art of leisure as basic factor of wellbeing and health. All studies, dealing with the art of leisure state a strong affinity between spaces and the components being detached from daily routine, and its time restrictions as well as concentrativeness and awareness. Simultaneously studies which investigate the recreation use of forests consistently describe that people percept their visits of forests as immersion into another world and hence into a possible space for the art of leisure.
Based on a literature review and on the assumptions that the perception of places and forests is dependent on societal discourses and individual frames, the papers' objective is to present a concept and methodology which is suitable to research the interdependencies of societal constructions of forests as a space for the art of leisure since the 19th century, and current individual perception of forests. Beyond the theoretical approach, the paper gives an overview regarding to the institutional embedment and the societal as well as the individual access to forest related art of leisure in history and present time.

art of leisure, recreation, discourse, frames

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77 - The Global Forest Environmental Frontier - What has changed, what has remained unchanged, how

KG I - 1199 (Uni Freiburg)

IUFRO17-3858 **The Climate Change Frontier: Power and Politics in Forest-based Adaptation and Mitigation, and a Green Economy**

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Abstract: Forests gained traction within the climate change negotiations over the past decades, e.g. through reducing emissions from avoided deforestation and forest degradation (REDD+) and forest ecosystem based adaptation. The importance of standing forests for adaptation and mitigation was acknowledged most recently in the Paris agreement. In the New York declaration private sector actors driving deforestation in many tropical countries committed to zero-deforestation goals. Investors such as the Norwegian pension fund 'de-vested' from deforestation-fueling investments. But is this urgency of maintaining tropical forests reflected in domestic policy arenas of forest rich countries, and in transformations of global commodity chains that were built on deforestation?
Evidence from 7 years of global comparative research and a meta-analysis of existing literature indicates that necessary transformations are not yet visible along three main transition axes: countries' policy responses, consumer and producer behavior, and so-called green investment behavior. So far, rhetoric of green development, green growth and bioeconomy in South and North dominates over actual policy action, with few notable exceptions. Analyses of actual trajectories of deforestation and tree loss show that business as usual of deforestation seems to continue. Global trade as well as investment flows do not yet reflect the ambitions voiced in fora such as the New York Declaration. Analyses of power and politics along the forest and climate change frontier, based on research of actors' discourses, incentive structures and power relations, reveal both obstacles and opportunities for transition pathways along the three transition axes.
Understanding barriers to transformative change and analyzing successes can provide crucial evidence for decision makers at all levels to further advance efforts to keep forests standing, domestically and globally, and realize forests' potential in achieving climate goals.

deforestation; policy; tropical forests; discourse

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IUFRO17-2881 **The Bioeconomy Frontier**

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Abstract: Nearly 30 years have passed since the publication of the Brundtland report in 1987, but it seems that the importance of the notion of sustainable development has slightly faded despite the fact that the United Nations last year agreed to Sustainable Development Goals and postulated a Sustainable Development Agenda until 2030 including related goals and targets.

In the meantime, a new concept "bioeconomy" or "bio-based economy" has risen from the ashes like a phoenix starting from mid-2000. More and more countries including the European Union are developing national bioeconomy strategies and investing large research funding amounts into bioeconomy related projects. The European Commission for instance has stated in its 2012 bioeconomy strategy that "Bioeconomy is Europe's response to key environmental challenges the world is facing already today". From a United States point of view bioeconomy "has emerged as an Obama Administration priority because of its tremendous potential for growth as well as the many other societal benefits it offers."

By the end of October 2013, a google search for the term "bioeconomy" produced 350,000 hits. Three years later in December 2016 the same term produced 722.000 hits. Has the importance of bioeconomy increased?

This paper seeks to review the political science literature to take stock of current bioeconomy policies and to assess whether frontiers in natural resource governance are shifting. Furthermore, it aims to understand whether and if the notion of bioeconomy changed the way governance is defined and practiced and to assess what has changed in relation to previous notions of sustainable development. Finally, it also aims to understand what has remained unchanged and provide a look into the future.

bioeconomy, review, political science

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IUFRO17-2039 **Forest-Community Relationships in the Age of Collaboration**

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Abstract: Community-based forestry is a global phenomenon. It takes various forms of devolution and decentralization in different nations, cultures, and forest ecosystems; but typically emphasizes local and community control of natural resource decisions in a given area. There is a substantial and longstanding literature on community-based forestry or community forest management in the developing world, in comparison to the majority of the developed world where collaboration and co-management, often emphasizing partnerships with government rather than full tenure transfer, appear to be more common paradigms. Common themes have included analysis of ecological, social, and environmental outcomes, governance structures, power relations, and social and institutional factors that drive successful collaboration. We provide a review and synthesis of current community-based forestry research, particularly to compare and contrast examples of governance systems and types of communities in developing and developed world contexts from our collective research experiences. We suggest future research and practice directions given the identified lacunae and current and future environmental governance trends.

Community forestry, collaboration, comanagement

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77 - The Global Forest Environmental Frontier - What has changed, what has remained unchanged, how

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IUFRO17-1238 **The Forest Environmental Frontier in Australia and New Zealand**

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Abstract: In some parts of the landscape, the forest environmental frontier in Australia and New Zealand has moved to the post-industrial forestry era. The harvesting of public native forests, and their conversion to other rural land uses, ended in New Zealand in 1987; in Australia, harvesting of public native forest harvesting was greatly curtailed in the decades to 2010, and their conversion to plantations ended in 2007. However, the scale of private forest conversion to other land uses in Australia has remained high. In both countries, tree plantations became the dominant resource for industrial wood production, and this has opened a new frontier for forest conflict between plantations and agriculture and in some plantation operations. Other conflict frontiers emerged in both counties over the role of forests in carbon sequestration, and in Australia over bioenergy, bushfire management, and catchment management. There has been some progress in Australia over its longest-standing forest environment frontier, that between Aboriginal Australians and more recent settlers, but their standing and agency do not yet parallel those of New Zealand's Maori people, realised under treaty settlements.

Australia, New Zealand, forest governance

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IUFRO17-1001 **Using international environmental governance interventions as a tool of territorialisation: the case of FLEGT and REDD+ in Laos**

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Abstract: Literature on natural resource governance suggest a trend of using policy initiatives - such as conservation &land titling - as tools for state territorisation. State territorisation is described as a phenomenon where states divide national territory in political &economic zones in order to control people and resources in those zones.
In this paper we explore how the Government of Laos (GoL) uses and misuses international initiatives - the FLEGT &REDD+ - as tools to justify and further its long-standing political and economic objectives; including eradication of shifting cultivation and promotion of plantation and hydropower development.
We use frameworks of state territorialisation and extra-territorialisation to frame our inquiry and analyses. We review the FLEGT &REDD+ pilot project landscape in Laos, focusing on key 3 projects as case studies. We analyse discourses surrounding forest carbon &illegal logging. Finally, we conduct key informant interviews with FLEGT &REDD+ project staff and state actors. We examine scope,scale,drivers of defor.&sectors included in the 2processes.
Our analysis indicates that while the main forest resources &deforestation occur in the south, GoL promotes REDD+ activities in the country's north, where shifting cultivation is widely practiced. We show how GoL strategically differentiates between "planned" & "unplanned" deforestation, when deciding on drivers of deforestation and on the scale of REDD+ pilot projects (large vs. small scale). "Planned deforestation" originates from plantations and development projects, while "unplanned" is mainly caused by small-scale activities, including shifting cultivation. Consequently, small-scale activities and local drivers of deforestation are included in the REDD+ pilots, while large-scale activities and drivers are left out. We discuss how illegal logging discourse is framed only around timber production, excluding sectors mainly responsible for forest decline (mining, hydro power, agriculture).

state territorialisation, FLEGT, REDD+, Laos.

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160 - Wood based fuels for transports - conditions for their market entry and impacts on the wood-using

KG I - 1228 (Uni Freiburg)

IUFRO17-3629 **Optimal use of woody biomass for biofuel production in Europe**

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Abstract: According to the ECOFYS report on "the ten most important short-term steps to limit warming to 1.5 °C", one strategy was to sell the last fossil fuel car by 2035. To reach this target each country has to manage and use its resources in an optimal, efficient and sustainable way. Forest residuals have become of interest for the production of biofuel providing a respect of the cascading use.
In that respect, a geographic explicit techno-economic model, BeWhere (www.iiasa.ac.at/bewhere), has been developed at the European scale (Europe 28, the Balkans countries, Turkey, Moldavia and Ukraine) at a 40km grid size, to assess the potential of bioenergy from non-food feedstock. Based on the minimization of the supply chain from feedstock collection to the final energy product distribution, the model identifies the optimal bioenergy production plants in terms of spatial location, technology and capacity. New production plants can be setup providing the existing woody based industries can meet their demand of feedstock, avoiding any competition between different forestry markets. The forestry feedstock includes for both conifers and non-conifers: Stumps from final fellings, stemwood from final fellings, stemwood from thinnings, logging residues from final fellings, logging residues from thinnings. For each type of feedstock, one or multiple technologies can be applied for either heat, electricity or biofuel production.
The model is run for different policy tools (e.g., carbon cost, biofuel support) and the optimal mix of technologies and biomass needed is optimized to reach a production cost competitive against the fossil fuel based reference system. The preliminary results show that large scale biofuel production plants are mainly located in the northern part of Europe, and methanol is the preferred biofuel. Nevertheless at higher carbon tax, the production of heat and power becomes more advantageous due to the higher emission substituted.

Europe, biofuel, BeWhere, energy target

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IUFRO17-2564 **Prospects for producing liquid wood-based biofuels and their impacts on the forest sector in Europe**

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Abstract: We considered economic potential for producing traffic biofuels from logging residues, roundwood and chips and the impacts such production could cause to the forest industry and wood-based heat and power supply in the European Economic Area. For this, we used a global model for the markets and trade of forest biomass and products, the EFI-GTM. Our results indicate that policy choices have strong impact on the allocation of biomass between heat, power and traffic biofuels. Hence the policy makers must have very clear goals for their preferred ways to solve the shift from fossil fuel based energy system to the less emission intensive one. Because large biorefinery investments take years and because in various parts of Europe the biomass availability is not yet of very strong concern in next decade, there is some time to adjust the policies. Former studies predict that increasing bioenergy in response to the goal of halting the climatic warming to 2 C will be a global phenomenon. Under that setting, the increased competition over biomass will be faced by all the regions. This and the relatively abundant biomass resources in Europe help the EEA forest industry to maintain its market shares.

Energy, biofuels, forest sector, biomass, modeling

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IUFRO17-2781 **Considerations in estimating residue based feedstock supply curves for biojet facilities in the northwestern United States**

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Abstract: The aviation industry has set ambitious decarbonization goals yet low fuel prices and environmental concerns remain critical barriers to investment and commercialization of biofuel production. One feedstock with promise to alleviate both those issues is logging residues. As a waste product, they have low landowner value and are typically piled and burned thus limiting additional greenhouse gas emissions. Low value doesn't necessarily indicate low cost as supply chain expenses can be considerable. Feedstock logistics are therefore a key aspect in biorefinery viability and knowledge of the spatial allocation of logging residues and how that allocation may change over time is fundamental. This study uses a spatially explicit economic model of U.S. forest products markets which balances harvest and log demand at regional mills over time. Resource supply is simulated at the national forest inventory plot where logging operations for products such as lumber, plywood and paper products occur. Logging residue availability at the plot level is further refined incorporating estimates of piled proportion, distance of piles from landings, and costs associated with extraction and utilization. Road network-based transportation data is then added to generate supply curves and maps for an array of desired biorefinery sites across the U.S. Northwest.

forest residuals, supply chain logistics, biofuels

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160 - Wood based fuels for transports - conditions for their market entry and impacts on the wood-using

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IUFRO17-3926 **Bioenergy from young dense stands - a long term sector analysis for Sweden**

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Abstract: The purpose of this presentation is to investigate the future role of harvesting trees for forest energy in young dense stands with novel systems and techniques as a silvicultural method in Swedish forestry. In order to accurately assess the potential and viability of new practices of increasing the supply of forest fuel, it is important to have good estimations of the entire basket of potential amounts of renewable energy sources. It is also important to link the supply of forest energy to the supply of timber going to sawmills and pulp mills since, firstly, the available amounts of residues are linked to harvests and, secondly, harvests determine the supply in the long term. Thus, any long term analysis of forest fuel supply need to embrace the entire sector. The current analysis encompasses a 100 year period with the demand side represented by demand functions for saw timber, pulpwood and forest energy. The supply stems from more than 10,000 NFI plots where each plot can deliver to between all major facilities within a transport distance of 300 km. The problem is based on a Model I forest model (with management regimes created by the Heureka system) and cast into an intertemporal partial equilibrium model. Given current demand the results show that dense stands with no precommercial thinning can represent a substantial share of forest energy. However, the increase comes about 40 years from now amounting to more than one third of total supply over a few decades. The total supply increases less; the increased volumes from young stands is partly substituted for pulpwood going to heating plants. With increased demand following a more developed bioeconomy the young stands become even more important as supplier of forest fuel when less pulpwood goes to heating plants.

forest fuel, partial equilibrium model. long term

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IUFRO17-2676 **Global trade of wood biomass for energy: a tradeoff between biofuels and pellets**

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Abstract: The choice of wood based fuels for transport is currently an open question, some regions favoring more electric cars while others biodiesel. Hence, it is risky for biomass exporting regions to commit wood based fuels production, which have high investment costs. This study investigates the tradeoff between wood based fuels and wood pellets by using the Global Biosphere Management Model (GLOBIOM). Transport costs of wood based fuels are lower than wood pellets, but wood pellets provide an option value of producing electricity for other sectors than transport. Hence, if the uncertainty about the future biodiesel demand is high enough then wood pellets production becomes a more favorable alternative despite of higher transport costs.

biofuels, pellets, trade

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174 - Connecting People to Forest Science: Innovative Communication Approaches for Delivering Science

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IUFRO17-106 **Knowledge sharing in Forestry**

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Abstract: Communication, information management, knowledge management, and knowledge sharing are a family of interlinked disciplines and activities that are essential to help development move from outputs (journal articles, and international public goods) to outcomes (changes in knowledge, behavior and decision-making). We see these interlinked disciplines and activities as an integral part of a "knowledge production process". They ensure that knowledge and information can be used by different stakeholders to support their own decision-making, and that ensure that all stakeholders are involved in the co-creation of knowledge. This paper examines the richness of concepts related to knowledge sharing and describes practical activities of knowledge sharing in Forestry, in particular the first Knowledge Share Fair held in Rome at FAO HQ during the third World Forestry Week in 2012, and the activities developed by the Center for International Forestry Research (CIFOR). Knowledge Sharing implies that everyone contributes with their knowledge. Impact happens through people, not simply by delivering information products or messages. The success of the initiatives described here were exactly the fact that participatory approaches were used given the participants opportunity to have a two way communication. These initiatives demonstrated how knowledge sharing methods and principles can open up meaningful spaces for face-to-face dialogues.

Knowledge sharing; Forestry

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IUFRO17-3780 **Forest communication: are we doing right? An online survey on public knowledge and perception of forests and forestry terminology in Italy**

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Abstract: Over the last decades the views and demands on forests by society have dramatically changed and concerns on how people perceive forests and forestry, as well as how to find appropriate communication tools have raised.
As many other Western European countries Italy has experienced an increase in forest areas: over the last 50 years forest cover has doubled, reaching about 35% of the Country. Forest expansion is among the most relevant land use changes undergoing at national scale, mostly as a consequence of farmland abandonment and natural forest growth. Meanwhile forestry issues remain mostly within the domain of specialized/technical bodies -both private and public ones- and limited information is made easily accessible and communicated to society at large. Building on these considerations, the research aims to investigate public knowledge and perception of the forest sector in Italy to gather information on how communication on the role of forests may be improved.
An online survey has been conducted in North-Eastern Italy to collect information on people's knowledge and perception of a broad range of forest-related aspects, including general knowledge of basic forest figures/data, familiarity with forestry terminology as well as issues like forest certification and recent developments in forest policy. Two-stage sampling has been adopted, with a stratification at first stage into mountain, lowland rural and urban population. Once finished with the survey, respondents were given access to correct answers and additional information.
Preliminary results indicate that, on average, people have limited familiarity with forestry issues and tend to underestimate the quantitative and qualitative relevance of both national and local forest resources. Findings also show some distorted perceptions -for example on extent and trends in forest cover- thus confirming the need to take action and fill the gap between public understanding and reality.

knowledge, perception, communication, survey,Italy

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174 - Connecting People to Forest Science: Innovative Communication Approaches for Delivering Science

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IUFRO17-3679 **Using Social Media to Promote a Forestry Conference: European Forum on Urban Forestry 2016 Case Study**

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Abstract: How to promote a forestry conference in the era of social media? In our presentation, we offer a methodological approach on communicating a forestry conference using a social media team and explain it using the practical example of European Forum on Urban Forestry 2016.

Our promotion of a forestry conference consisted of 3 phases:
1.Strategy and Team-building
2.Promotion and Marketing
3.Covering the event and dissemination

Strategy and Team-building

Successful conference promotion begins with a good communication strategy, with special attention paid to communication aims and goals. The formation of a communications team is an integral part and the first step of generating on-line and media momentum. To promote the European Forum on Urban Forestry 2016, a communication team that consisted of organizer's employees and volunteers was formed. The team met approx. once per week to create a team-oriented culture and build a strong basis for the project.

Promotion and Marketing

The promotion and marketing of the EFUF 2016 began with a stakeholder analysis, in which potential attendees of the conference were identified and contact lists were prepared. The promotion included a e-newsletters, promotion via social media, a blog competition and other approaches and was successful - the attendance goal was reached. The #EFUF2016 blog reached over 2800 readers from 90 countries through invited, organizer's and competitive blog posts.

Social Reporting from the Conference

A team of 10 active social media reporters ensured that the conference topics and presenters were noticed not only by 80 conference participants, but by almost 25.000 interested people on-line. Over 1000 tweets using the official #EFUF2016 label were sent during the conference. Interested professionals were kept up-to-date through daily blog posts, photos and newsletters.

The promotion and social media coverage were highly regarded by the organizers and the participants (physical and virtual).

social, media, conference, promotion, forestry

KG I - 1009 (Uni Freiburg)

IUFRO17-2485 **Australia's approach for connecting forests, science and people in national forest reporting**

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Abstract: It is challenging to produce comprehensive interdisciplinary national reports on forests. Australia has achieved this every five years since 1998, with a fifth 'state of the forests' report due in 2018. Each report fulfils national and international reporting requirements, based on a Montréal Process framework of seven criteria and 44 indicators of forest conservation and sustainable management, and describes broad forest values that society seeks to maintain. These values cover biological diversity, productive capacity, health, soil, water, carbon, and economic, social and legal aspects of forests. Data are compiled by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) from diverse sources around Australia, in collaboration with the Australian, state and territory governments. ABARES also contributes interdisciplinary expertise in data analysis. Industry decision-makers, policy-makers, researchers, educators, and the wider community are users of the reports. Increasingly, communication of findings occurs through innovative written, visual, online and hardcopy products. For *Australia's State of the Forests Report 2018*, the range of digital products will include interactive PDF documents providing access to the data behind every table and figure and to print-quality maps, accessible documents for vision-impaired users, and spatial datasets. Other proposed digital products include infographic-style data visualisations.

Australia, forests report, science, economics

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IUFRO17-2500 **Raising awareness on forest genetic diversity through Wikipedia**

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Abstract: Genetic diversity is crucial to make forests resilient and prepared for the future climate conditions. However, forest genetic resources (FGR) are not a well visible dimension of biodiversity so hardly perceived as significant. The topic is challenging to explain to non-experts thus it does not attract attention of media and is often overlooked by policymakers.

In its recently redesigned website, the European Forest Genetic Resources Programme (EUFORGEN) has showcased its resources by creating 107 pages on the most important forest species in Europe featuring their main characteristics, distribution maps, location of genetic conservation units and related publications.

Subsequently, the species pages were linked to the 'Wikipedia' to communicate the value of forest genetic resources to a wider audience. The results of the free online encyclopedia rank among on top in Google search for species, so linking EUFORGEN species pages to Wikipedia is directly contributing to raising awareness on FGR and steering users' attention to the core work of EUFORGEN. The task required an adjustment of the intellectual property rights of the website and consisted of several steps, recommended for its various contents (photographs, publications, distribution maps).

forest, genetics, communication, knowledge sharing

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77 - The Global Forest Environmental Frontier - What has changed, what has remained unchanged, how

KG I - 1199 (Uni Freiburg)

IUFRO17-3145 **The forest environmental frontier in the Congo basin: past, present and future**

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Abstract: Since independence in the 1960s, the distribution of natural resources in the Congo basin has been shaped by many latent and overt institutional struggles, underpinned by (new and pre-existing) power asymmetries, which fundamentally altered dynamics within the forest environmental frontier over time. Such struggles occur today in a complex multi-layered institutional reality, linked to the growing number of commodities - and intervening actors - often found on the same piece of land. At times (violent) local conflicts determine the adoption of new policies and the creation of new institutions, and vice-versa, while physical confrontation may happen among different intervening parties, e.g. local communities vs. private companies, local communities vs. local authorities (including "elites" established or imposed by the ex-colonial masters), private companies vs. private companies, NGOs (national and international) vs. private companies. Similarly, confrontation may occur between donors vs. government/ministries, ministries vs. ministries (especially over who own the responsibility over a certain resource), and more recently, central vs. local governments and local institutions vs. national ones. In this paper, we unpack those dyadic conflicts systematically, by examining over time (a) sources of conflict; (b) the institutional spaces in which conflicts occur; (c) the manner in which conflicts are manifested; and (d) the outcomes of conflicts.

Through this analysis, we show how conflicts have changed over time and the resultant implications for the Congo Basin forest environmental frontier. This will framed around broader changes in the macro- and micro-political and economic structure that have been brought about by structural adjustments plans, reduced government enforcement capacity, and shifting sectoral priorities (e.g. from timber to minerals, to commercial agriculture).

Congo basin; timber; mining; agriculture; conflict

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IUFRO17-831 **From forest frontier to forest landscape arena: A trajectory of forest development aspirations, discourse and practice in Amazonia**

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Abstract: The Amazon basin contains the largest contiguous reserve of tropical rainforest. The region has drawn interest from outside the region, since European travelers arrived in South America, and continued during the rubber boom and equally when tropical deforestation became a global concern. The Amazon has been at the center of debates and policies and practices, whose origin can be located in the 1980s, that reflect the tension between the conservation of global environmental commons and the need for national development drawing on domestic natural resources. Since then important changes have occurred in efforts to exploit resources, but also in policies and administration to pull the region into national economic modernization. The latter include efforts and discourses to pursue sustainable development, i.e. the combination of economic development and natural resource conservation. Concurringly, the socio-economic reality of the Amazon basin has purportedly changed profoundly. These changes have also affected the debates on the Amazon basin, including of the composition of actors who participate in these debates, of what are development or conservation priorities, and what are the best options to pursue those priorities. The recent revaluation of the global forest estate for its role in climate change mitigation has added new dimensions to the controversies of how to prioritize or reconcile development and natural resource conservation. In this paper we will review the shifts in resource use, national and international policies and administration related to the Amazon basin, the changed configuration of Amazon stakeholders who claim rights and benefits, and the evolution of the main arguments and ideas on resource use and conservation priorities, or options to pursue those. The latter will include reflections on anticipated trends and scenarios of Amazonian resources use challenges.

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IUFRO17-634 **The Forest Environmental Frontier in North America**

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Abstract: The US forest governance system has transformed over the last 30 years. Today's approaches emphasize: integrated planning focused on outcomes, such as resilience and restoration, rather than outputs; collaboration with stakeholders participating at multiple scales of governance; and an increased emphasis on ecosystem services in light of climate change. On public lands, we have seen governance changes to encourage large-scale, strategic planning and support multi-stakeholder collaboration. On private lands, there have been significant changes to the policies and actors involved in land management, with measurable effects on forest management outcomes. What have social scientists learned as these experiments in forest governance have taken place and what is the research agenda for the next 30 years? For example, while we understand the institutional barriers to more adaptive forms of governance, we now face important questions regarding the changing scales of planning and the nature of and pathway to governance institutions that will support improved strategic thinking, integration of science, inclusivity, and the accomplishment of desired outcomes. Across several focal areas, this talk will discuss lessons learned, highlight persistent knowledge gaps, and identify the research frontier.

resilience, restoration, US forest governance

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IUFRO17-1904 **The Politics of the Forest Environmental Nexus in Europe**

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Abstract: The ecological policy paradigm of conservation and sustainable use of forest ecosystems has gained globally a significant importance in both science and policy over the last two decades. It has led to the design of new forest-related EU and national policies in the fields of nature protection and biodiversity conservation, climate change mitigation and adaptation, ecological sustainability of global timber trade, and sustainable timber-based bio-economy. However, the multi-level governance of these forest environmental questions has been marked by both increasing conflicts and/or strategic cooperation between distinct environmental protection and distinct forest sector interests. In this study, we will trace changes and stability in the policy process in four topical case studies in the European multi-level governance context. The cases include (i.) the EU Habitats and Birds Directives / Natura 2000 policy; (ii.) the EU Timber Regulation, (iii.) EU Bioenergy Policy (sustainability criteria and indicators under the EU-RES) and EU Climate Policy. We will draw on a literature review, interviews and content analysis as well as on a recent theory of shifting coalitions and policy change to understand and explain the conflicts and politics of the European forest environmental frontier. In particular, we will study stability and change in policy beliefs/interests, political influence as well as shifts in coalitional politics as regards conflict and cooperation between the involved state and non-state policy actors. Finally, we will compare changes and stability in conflict and cooperation across these four policy fields, and draw conclusions on the forest environmental frontier in Europe in terms of theory and practice.

conflicts, policy change, shifting coalitions

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IUFRO17-2018 **Legality frontiers between State and local communities in Myanmar, Cambodia, Laos and Indonesia**

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Abstract: Many Southeast Asian countries follow neoliberal agricultural and industrial development strategies and embark on community based natural resource management reforms. Nevertheless, they maintain strong, centralized, crony governance systems. Large scale industrial concessions fit these systems well, but tend to overrule environmental and social concerns, e.g. through primary forest conversion and forceful evictions of local communities. Also, local communities' extraction of commercially valuable forest products is often not welcomed and sometimes criminalized, detracting from their incentives to protect natural resources. Alongside these developments, legality has emerged as a key concept in global attempts to regulate wood supply chains and sustainability. However, if States are not accountable to their populations, then legality will hardly cater for local communities' interests. In this paper we focus on the legality frontiers between state and communities in Myanmar, Cambodia, Laos and Indonesia. We aim to 1) compare the four countries with regard to "crony-ness" and degree of centralization; 2) identify and compare the main antagonisms encountered between state and community forestry along legality frontiers, including consequences for incentive structures and distributive effects; and, finally, 3) discuss whether and how legality might contribute to incentive based forest conservation and community development in crony states.

Southeast Asia, Communities, legality, State

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IUFRO17-560 **Governance of green city areas on the background of the concept of "urban forestry" in Europe - case study of Poznan (Poland).**

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Abstract: Poznan is one of the most important urban centers in the country. The main spatial assumptions in Poznan are a wedge-ring system of greenery in the city and a division of the communication system into separated units. The city area is 261.9 km sq., the share of built-up areas amounts to 44% , while 48% are agricultural areas, woodlands and greenery. Most of the urban lands are the property of municipal units or private landowners (by 36%). The area of municipal forests amounts to 2576 ha. They are divided into 4 municipal forest districts: Zieliniec, Antoninek, Marcelin and Strzeszynek. The governance of the municipal green areas which represent parks is assigned to the Management Board of Municipal Greenery. On the other hand, green areas and single trees located in the road lanes of the city are managed by the Municipal Roads Authorities. Each of the governance units has its own competencies and objectives of the activity. On the basis of the concept of urban forestry, which assumes the systemic treatment of the greenery and woodlands within the city, in Poznan and many other Polish cities, the separation of competences between the entities managing the different categories of green areas is noticed. The authors present the characteristics of the management of green areas in Poznan and the strengths and weaknesses the adopted solutions.

governance, urban forest, forest management

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IUFRO17-1264 **Drivers and barriers of urban forest governance: Lessons from the Republic of Korea case**

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Abstract: Multiple interests exist in managing state forests and forest conflicts and cooperation among different interests have emerged. This study aims to investigate drivers and barriers of governance in managing state forests in the Republic of Korea (ROK). Three principles of governance were selected as analysis foci; participation, accountability and transparency. We selected a case of urban forest management in the city of Daejeon where is located in the middle of ROK. In this case different stakeholders including the Regional Forest Service, enterprise and forest NGO have established a contract for 10 year- joint forest management according to the Article 15 of State Forest Administration and Management Act. Within the project the stakeholders took part in planting and tending trees with citizens. The practices and process of joint forest management was examined depending on participation, accountability and transparency. As a result, this research indicates drivers and barriers of urban forest governance in ROK. As well it recommends some suggestion for good forest governance.

accountability, participation; transparency

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IUFRO17-3357 **Impact of national forest protection contract on local people's trust in government**

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Abstract:
The success of national forest governance relies on the trust of people in the government. For the government to manage national forests efficiently, local people's trust in national forests administration is important.
In South Korea, Korea Forest Service(KFS) introduced a collaborative forest management scheme to manage national forests more efficiently in 2008. As a part of collaborative national forests management scheme, KFS contracts with local communities for national forests protection. Under this contract, local people are given the right to access to national forests and collect non-timber forest products in return to their duty of protecting the forests.
This paper aims to understand the impact of national forest protection contract(NFPC) on local people's trust in government. To test a hypothesis that collaborative management of national forests can improve local people's trust in the government, the authors interviewed local people who reside in the communities nearby national forests and measure the level of their trust in national forest administration. Two groups of households were selected to compare their trust; one participants of NFPC and non-participants. The factors influencing local people's trust in national forest administration were identified with quantitative analysis.

collaborative management, trust, national forest

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IUFRO17-3962 **Positions revisited? An analysis of responses to public consultation concerning revisions of the Swiss Forest Act between 1993 and 2016**

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Abstract: Swiss forest policy has become rather dynamic during the last two decades, after a long time of stability. The first revision of the Swiss Forest Act dates back to 1993 and following the elaboration of the Swiss National Forest Program and its failure to trigger a comprehensive revision of the forest law in 2005, it has now been possible to adopt revision proposals at several occasions during the current decade. For all those policy processes, the administration had organized a broad consultation process, as it is always done at the end of the pre-parliamentary coordination.

In the public consultation phase, all interest associations as well as the sub-national governments are invited to submit written comments on the revision proposal that had been prepared by the forest administration before it is submitted to parliament. These documents reveal how the different actors' position themselves relative to the policy proposal. Applying text analysis to these answers allows eliciting the policy positions they contain.

Since 1993 some issues have been recurring: protection of the forest area, subsidies for forest owners, management restrictions concerning biodiversity, etc. The analysis compares proposals and policy positions relative to these proposals over time and thus allows examining, first, how policy proposals concerning these issues have evolved and whether the positions of the actors relative to the proposals have remained consistent with the positions expressed in the past. Presumably inconsistent changes might give an indication for policy learning. As Swiss Forest policy is quite strongly decentralized, the homogeneity of the positions of sub-national actors is particularly important for how policy positions evolve.

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IUFRO17-2143 **Coordinating Collaborative Governance of Forest Water at the National Level**

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Abstract: The virtues of a collaborative approach to the management of water resources, including forest water, have been stressed by both research literature and legislation. An example of the latter is the EU Water Framework Directive (WFD) which calls for a holistic approach to water resource management from a river basin perspective. While the main institutions responsible for collaborative management are at the local-regional level, as river basins often exceed local but rarely reach national boundaries, they must also adhere to national policy priorities. In accordance with the so called sector responsibility, the coordinating role for setting forest water policy goals was taken upon by the Swedish Forestry Agency (SFA). The Swedish Agency for Marine and Water Management maintains the overall monitoring and reporting role for the WFD. However, since there are potential conflicts between forest production and water quality goals, the SFA's leadership role within forest water governance is not completely unproblematic. Through a case study of the SFA led "Dialogue Project" at the national level, this paper aims at investigating how collaborative governance has been approached and effectuated in practice. Broader questions concerning the role of coordinating institutions, their primary resource focus and thus their inclusiveness, the process outcome as well as its effectiveness in relation to forest water policy making will be discussed.

Coll. Forest Water Gov., EU WFD, Coord. Inst.

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IUFRO17-2026 **Relevance of the "forests and health topic" for the future dialogue with people and possibilities for Forest pedagogy**

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Abstract: The relation between forest environments and human health has gained increasing attention the latest decade. While the subject has been on the research agenda since the 1960s, it is not until recent, longitudinal trials and randomized experiments have been published that the topic has reached all the way to global policy agendas. This enhances the opportunities for communicating between scientists, policy makers and practitioners in various sectors. These opportunities must not be missed and therefore evidence needs to be implied in practice. Research has shown that it is important that the relation to nature is established in early life. This is of value for fostering a sense for the environment among children and thus encouraging ecological lifestyles. Equally, during childhood the positive benefits of forests are particularly pronounced. For example, studies have shown that children's wellbeing, cognitive development and attention skills are significantly improved in areas with more natural environments. This provides a strong impetus for using forests as natural classrooms, facilitating children's learning while simultaneously engaging them in the environmental friendly behaviours. Forest pedagogy can thus have an immediate impact, but also across the life course.

children's health, forest schools, education

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IUFRO17-1130 **Forestpedagogy - platform for the cross border dialogue between forestry and society**

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Abstract: In Europe, forestry is currently facing a number of challenges including challenge of communication with the public. The international cooperation in the field of Forestpedagogy can be efficient incubator for the creation of sustainable partnerships for improving communication between forestry and general public. The study is focused on the presentation of cooperation between forestry institutions and other types of organizations in Slovakia, Ukraine and Norway. In the first stage of the project "Forests for society - "Forests without barriers a survey focused on needs demands for Forestpedagogy activities has been conducted in the border region of Slovakia and Ukraine. Three target groups were involved in the survey: schools, forest visitors, and disable people. Based on this survey, the training program for Forest pedagogy and ecotourism was developed. Furthermore, the transfer of best practices of Forestpedagogy from Slovakia and Norway to Ukraine was ensured. During the project implementation the interactive objects for Forestpedagogy and ecotourism were built. The main project output is the creation of the cross border Slovak-Ukrainian cluster. The cluster is represented by different forestry organizations (state, public, private) and environmental organizations which promise to become one of the platforms of increasing mutual dialogue between forestry and society.

communication, Forestpedagogy, cooperation

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IUFRO17-951 **Fostering Sustainable Development (SD) in the Context of Forest Education**

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Abstract: To foster sustainable knowledge acquisition and knowledge transfer on forest topics in primary schools three learning units were developed according to a moderate constructivist learning approach: (1) Planting a tree in the forest, (2) Tracks in the forest, and (3) Ranger kids. Each learning unit comprises 10 to 14 lessons and a half-day in the forest with a strict three-step procedure: Preparation of main topics in the classroom with the teacher, knowledge impression with the forester visiting the forest, and post-processing of the content with the teacher in class. In 18 classes, one learning unit was realized and evaluated with teachers, foresters, students, and parents.
The research questions were;
- How are the learning units evaluated from the participants?
- How far could SD competencies be supported?
- How is the teacher-forester-cooperation evaluated?
All participants evaluated the learning units didactically and with regards to content predominantly positive. Regarding SD competencies students showed both a higher knowledge acquisition and a higher transfer on forest topics. Specifically, learners got sensitive to make own contributions on forest topics. The teacher-forester cooperation was very positive, specifically in regard of coordinating content-specific issues. All learning units were published with oekom publisher.

sustainable development; forest education;

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IUFRO17-1675 **Forestpedagogy - challenged to climb the higher steps of Education for Sustainable Development**

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Abstract: In the last years awareness and place-value of Forestpedgogy raised in a lot of states worldwide. The forest sector is emphasizing more and more, that Forests and their sustainable management is an excellent model for learning and that Forestpedagogy is able to give important inputs for a huge spectrum of personal acting- and shaping-competences. So Forestpedagogy - offers shouldn't mainly focus on transmitting knowledge, but preferably motivate people to get conscious for taking responsibility.
Most of the traditional offers are already fulfilling the first steps of Education for Sustainable Development (ESD) like
-Learning (again) to enjoy the outdoors
-experiencing and observing nature
-understanding ecological correlations
-exploring the interplay of man and nature
But Forestpedagogy is especially challenged to give opportunities for making decisions on environmental issues and to inspire the participants for taking over concrete responsibilities and for growing mature in this responsibility. When this is successful, Forestpedagogy gives valuable contributions to ESD.

This presentation wants to show why Forestpedagogy is needed to develop forest-dialogues and how our dialogue-partners can learn not only about forests, but about values like respect for nature, consideration to fellow-being and life-being, responsibility, tolerance, solidarity between generations as well as global and long-term thinking and acting. People can improve creativity and imagination, cooperative- and action-competences, interdisciplinary thinking, curiosity, concentration and social behaviour.
While people are offered free space for self-discovering-learning, nature-near living spaces, natural habitats and rich biodiversity they are also stimulated to contemplate and reflect about the results of acting, their own role in the context of nature or society and their possibilities to change the own acting and attitudes in everyday life

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IUFRO17-1134 **Forest Research and networking in an ever-changing environment: The History of IUFRO**

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Abstract: 125 years ago the Forestry Research Stations of Germany, Austria and Switzerland founded the "International Union of Forestry Research Stations" in Eberswalde, Germany. The purpose was to promote forestry research in the broadest sense, to strengthen cooperation among the scientists and member institutions, and to publish the results of the research of its members. Originating from this small group it developed to a global organization which includes over 650 member organizations, connects the research results of around 15,000 scientists, and makes them available to forestry policy.

The paper will illustrate the development of IUFRO during this long period with regard to research topics, organization structures, and internal and external cooperation and networking in the context of changing political and environmental conditions, economic developments and social demands. It mainly relies on archive material stored in the IUFRO Headquarters. At the beginning the knowledge related to growth and yield and technical methods of measurement were at the forefront of the discussion. Since then the understanding of the interdependencies of technical measures and social developments and its creative power of supra-regional importance has enhanced the theme. The pure economic consideration of forestry lost its weight in the frame of industrial economy as a whole. However, its social components have increased but in the inverse ratio. The study will exemplify how it was possible that the idea of a free and non-political collaboration was so strong that it has lasted for 125 years within a dramatically changing world. Changes in the forest sector included globalization, governance reform, multisectoral relations, diversified products, and the demand for greater social and environmental focus. These encouraged parallel changes in research towards interdisciplinary cooperation and the sharing of new technologies especially information and communication.

history, research, networking, forest policy

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IUFRO17-3842 **Education, landscape approach and transdisciplinarity as tools to bridge policy-science-people barriers**

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Abstract: The portfolios of benefits from forests vary in time and space. Today sustainable forest management policy requires that forestry should deliver goods, habitats for wild species, and human well-being (jobs, social capital, health). Using Sweden as an example we analyse policy-science-people barriers using the cycle of (1) policy formulation, (2) implementation, (3) management and (4) evaluation. Policy formulation in the Swedish forest programme process aims at multiple-use. However, stakeholder and researcher representation reflects this poorly. Regarding implementation, we observed a focus on intensification and out-door recreation in urban settings, but neither on biodiversity conservation nor rural development based on forests' natural and cultural values. Concerning management, in spite of policy requesting multiple benefits, clear-felling systems totally dominate. Moreover, spatial planning to ensure functionality of habitat networks is poorly developed in spite of solid evidence-based knowledge. Finally, while monitoring as a base for evaluation of policy implementation is effective regarding wood, assessment of ecological and social consequences is very limited. We use these observations to develop three approaches to bridge these barriers: (1) broadening of forest management education, (2) implementation of landscape approaches like Model Forest, and (3) transdisciplinary knowledge production and learning.

knowledge production, collaborative learning

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IUFRO17-752 **Spruce or not? Contextual and attitudinal drivers behind the choice of tree species in Southern Sweden**

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Abstract: The ecological suitability of Norway spruce (Picea abies) in southern Sweden remains uncertain in a future warmer climate. In 2005 and 2007 severe storms exposed the risks with the current spruce oriented forestry. The reforestation after the storms was largely conducted by private forest owners who were offered grants to support regeneration with broadleaves. The previous practices however remained intact, with spruce occupying 90% of the planted area. Based on qualitative interviews and applying the practice based approach this study investigates factors and motivations shaping forest owners choice of species. The analysis reveals that continued reforestation with Norway spruce was a result of path-dependencies of practices strongly supported by the species' superior profitability and a high browsing pressure on Scots pine (Pinus sylvestris). Risk awareness, consideration to forest aesthetics and curiosity were the main attitudinal drivers in favour of regeneration with other species than spruce. Our analysis reveals naturally regenerated birch (Betula spp.) as a viable but previously overlooked pathway to increased species diversity. This study highlights barriers for the implementation of risk spreading strategies in southern Sweden. Forest owners need to abandon old habits but key elements of their contextual setting do not facilitate such a shift.

Reforestation; Experiential knowledge.

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IUFRO17-3092 **Planted forests in emerging economies: Best practices for sustainable and responsible investments**

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Abstract: Investments in industrial-scale planted forests have grown exponentially in recent years, and current assets under management total USD 70-80 billion, up from about USD 1 billion in 1980. Once almost exclusively focused on timber production, investments are now rapidly broadening their scope to embrace products and services that include ecosystem services, bioenergy and certified forest products.
Concurrently, the rapid growth of investments in plantations, notably in the tropics, has fostered controversies that are becoming more prominent and critical and that need to be faced by investors.
These are major reasons why investment companies and fund managers are increasingly interested in using sustainable and responsible investment (SRI) tools (e.g. standards, guidelines, and codes of conduct) that help them ascertain whether planted forests assets are 'safe' or 'risk-free' as far as environmental, social and governance (ESG) issues are concerned.

However, a classification system for SRI tools in the field of planted forests still lacks consensus. The present study therefore has two objectives: first, to identify, describe and analyze the tools that have been designed in order to promote SRIs in planted forests; and second, to suggest a framework for the evaluation of SRI tools vis-à-vis their capacity to address ESG issues in relation to investments in planted forests, with a longer-term aim of improving the SRI tools of the future.

An analysis of 121 investments in emerging economies enabled us to identify 339 organizations (i.e. stakeholders involved in the SRI process) and 50 SRI tools.

The classification of the 50 SRI tools based on the above mentioned set of variables allowed us to define an ESG Reference Document for quality assessment of the SRI tools.
Overall, findings indicate that very few SRI tools are designed in ways that take adequate account of the specific social and environmental sustainability issues relevant to planted forests.

investments, planted forests, sustainability

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IUFRO17-864 **The State and Future of Forest Carbon Monitoring in Africa in the Context of Climate Change Mitigation**

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Abstract: Africa has some of the most carbon dense forests such as the forests of the Congo-basin and extensive woodlands and vegetation of global significance. Climate change mitigation actions such as REDD+ will require, among others, an unprecedented technical capacity for monitoring, reporting and verification of carbon emissions and removals related to these forests. A functional forest carbon monitoring, reporting and verification system requires inventories of forest area, carbon stock densities and changes over time, both for the construction of forest reference emissions level and accounting of the actual emissions and removals. Such systems are essentially lacking in developing countries, particularly in Africa. The purpose of this presentation is to contribute to a better understanding of the state and the future of forest carbon monitoring and reporting in Africa. We argue that monitoring and reporting capacities in Africa fall short of the stringent requirements of the methodological guidance (such as the IPCC guidance and guidelines) for monitoring, reporting and verification, and this may weaken the prospects for successfully implementing mitigation actions such as REDD+ in the continent. We present the challenges and prospects in the national forest inventory, remote sensing and carbon accounting and reporting infrastructures, while demonstrating the contribution of forest sciences using examples. We suggest a North-South as well as South-South collaboration, and knowledge and skill transfer will help Africa to leapfrog in forest carbon monitoring and reporting. These could be delivered through transfer of free or subsidized remote sensing data, assistance in technical capacity building for data management and sharing experiences that exist among developed countries (also called Annex I countries in the contest of GHG reporting) that traditionally compile emissions and removal reports to the UNFCCC and its Kyoto protocol.

Forest-carbon, Monitoring, Africa, REDD+

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IUFRO17-1295 **Exclusion of Community Forest Associations in decision making and its impact on forest condition; Case Study of Arabuko Sokoke, Upper Imenti and Ramogi forests, Kenya**

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Abstract:

By Roxventa Othim , Paul O. Ongugo and Benjamin Owuor

Abstract

Governance of forestry structure through Participatory Forest Management is backed by Forest Act 2005, which is undergoing a review process. It has been shown that adoption of PFM in some forest stations has resulted in improved forest condition. Community Forest Associations form the major governance structure for implementing PFM.
The Constitution of Kenya 2010 created a devolved governance structure which created County Governments to take services closer to local communities. The process of devolving the sector has left out communities in decision making and formulation of rules. It is apparent that CFAs, which represent communities, are not being given their rightful place in the process. Because of this exclusion, the participation of CFAs in forest management is likely to be lower than it was before devolution and this may have an impact on the way forests are managed. The
objective of this study was to look at the level of CFA involvement in PFM implementation through the formulation of rules and decision-making, how such involvement has shaped forest condition. The study used International Forestry Resources and Institutions (IFRI) tools and methodology to analyze CFAs' roles, activities and participation in for inclusive governance in the forest sector. The study was conducted on three forests: Arabuko-Sokoke, Upper Imenti and Ramogi forests where CFAs are involved in managing different types of forest under varying tenure arrangements.
Preliminary results showed that where rules were formulated without the participation of local communities, the forests were more degraded than where local communities were involved.

Key words: Community forest associations, local communities, rules and decision making

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IUFRO17-2871 **How to cut a virgin forest, a Romanian legal perspective**

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Abstract: Even though virgin forests are explicitly legally protected since 2008 in Romania, the area covered by such ecosystems of long-term importance for Europe was continuously decreasing ever since. In the present study the legal frame which made this undesired fact possible is analysed. There were identified several main reasons for such a decrease, ranging from restitution and misunderstanding of differences between ownership rights and usage rights, to archaic governance models and legislation. It seems that Romanian virgin forests, which are covering less than 3% of the Romanian forests, are affected by illegal logging, camouflaged under archaic legislation and command and control governance. This state of the facts is described here using data from three case studies, which took place during the years 2013-2016. What is a fact of great concern is that no legal actions were taken against those who violated the forest law and facilitated cuttings of such virgin forests of paramount importance. Lack of action from the state authorities is increasing the concerns of the local public and European professionals as well, especially since the phenomenon seems to be contagious and to be exported.

illegal logging, governance models, EU

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IUFRO17-334 **Collaborating with the state: Explaining the dynamics of deliberations and political decision-making in the adoption of a National Forest Program**

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Abstract: Over the last two decades intergovernmental organizations have supported the initiation of National Forest Programs (NFPs): forums for joint deliberation by the state, private companies and NGOs that are intended to resolve conflicts over forestry and enhance sustainability. However, NFPs do not always reconcile conflicting perspectives or produce legitimate strategies for sustainable forestry. Thus, further analysis of NFPs' organization and processes is required, including exploration of effective means to address such challenges in early stages. These are key concerns of this paper, focusing on the process to establish a Swedish NFP. This is an especially intriguing case since Sweden has been a highly significant exception to the general European adoption of formal NFP processes. In Sweden, one of Europe's most extensively forested nations, the government only recently decided to initiate a formal process to adopt an NFP as part of efforts to meet National Environmental Quality Objectives. Possibilities for an NFP to constitute a new arena for deliberation and consensus-building, producing forest policy statements and action plans considered legitimate by various stakeholders, are discussed. A number of key challenges are identified through a theoretical framework based on notions regarding the input, throughput and output legitimacy of collaborative governance. Analysis of official documentation, records of public hearings, stakeholder comments and semi-structured interviews suggests that the process to launch and implement a Swedish NFP will continually face a number of challenges, most importantly, balancing production and conservation values in the emerging bioeconomy and securing long-term and equal stakeholder participation.

Forest governance, deliberation, forest program

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IUFRO17-3763 **Increasing deregulation of the forest sector - implications for actors' cooperation**

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Abstract: Competition law and anti-monopoly regulations raise the call for deregulation of the forest sector in Germany. In this context the federal state of Baden-Wuerttemberg is obliged to change its policy referring to the extension services regarding to private and municipal forest owners.
Based on the approach of actor centered institutionalism, capabilities and orientations, constellations and interaction of forest actors will be analyzed to describe path dependencies and possibilities for path creation of actors within the forest sector. Especially new developed or adopted cooperation between different forest owners, private and state foresters and enterprises along the value added chain is in the focus of the presented study. The results base on group discussions and qualitative interviews with private and municipal forest owners, forest officers and private service provider.
Beyond the theoretical approach, the paper contains references how to develop the ongoing forest policy change and enable binding agreements as well as cooperative decision making between the actors of the forest sector.

policy change, actors, institutions, path

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IUFRO17-3037 **The politics of forest governance**

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Abstract: Most - if not all forest conservation challenges - including people's livelihoods, carbon sequestration, the bio-economy, biodiversity conservation, and ecosystem services delivery - are also inherently political challenges that require appropriate and legitimate responses. We argue that scholars need to address these political dimension of forest problems more explicitly. Doing so is often coined 'the politics of governance'. This paper explores this theme by reflecting upon a broad set of literature within the field of forest policy and politics. In the literature, we explore topics of power imbalances in community forestry, winners and losers from forest certification, land grabbing by forest concessions, forest enclosures through REDD+, democratic and participatory experiments in forest governance, legal logging initiatives, and forest restoration initiatives as sustainable development diplomacy. By collecting examples from critical policy studies, political ecology, discourse analysis, practice theory, power analysis, and governmentality studies, we aim to assemble a integrated understanding of what the politics of forest governance entail. Doing so, we additionally seek to explore ideas of how to make forest governance more democratic, just, and inclusive.

governmentality, discourse, governance, critical

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IUFRO17-2205 **Obstacles to the Ecosystem Approach in Aquitaine forestry: analyzing coupling systems between science and politics in third party governance**

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Abstract: Forest management is a prominent battleground for sustainable governance of natural resources. Whereas in other fields an Ecosystem Approach (EA) to governance has become the norm, resulting in a redistribution of power among governing actors, its place in forest politics remains contested.

I study obstacles to the spread of an EA in New Aquitaine, France, focusing on third-party governance and competing strategies to occupy the environmental certification market. I argue that the Forest Stewardship Council's [1] certification frame is close to an EA, yet its uptake in New Aquitaine is small compared to the Program for the Endorsement of Forest Certification's [2] , which draw nearer to a more classical sustainable production approach. Applying a new conceptual framework (the 4As) from the ECOGOV [3] project , I explain this by analyzing coupling systems between science and politics. The 4A framework identifies four types of mediation dynamics, or coupling practices, between knowledge and regulation: 'Acquisition', 'Aggregation', 'Articulation' and 'Accumulation'. I argue a knowledge based governance framework such as the EA must be operated by a coupling system regrouping in a coherent pattern all four types of coupling practices to be sucessful. A key challenge resides in the FSC's coupling system as it does not implement all four coupling practices.

Overall, I argue that political practices and coalitions around these 4As can be studied to grasp obstacles and favorable factors towards an EA to forest governance and hence the re-configuration of 'winners and losers' in certification and forest governance.

[1] A certification scheme mainly supported by NGOs, such as WWF.
[2] A certification scheme mainly supported by stakeholders representative.
[3] ECOGOV: A political sociology of ECOsystem sciences: theories, narratives, interactions and GOVernance (LabEx COTE, Bordeaux University). Project leader: Caitríona Carter. Forest Partners: EFI ATLANTIC; UMR BIOGECO, INRA

coupling practices, competing governance scheme

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38 - Impacts of voluntary forest management certification: challenges and solutions in measuring results

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IUFRO17-2656 **Monitoring and evaluating effects and impacts for FSC Forest management certification**

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Abstract: Introducing Session 38 of the congress, the paper will discuss the FSC Monitoring and Evaluation scheme and the requirements of the ISEAL Code of Good Practice for Assessing the Impacts of Social and Environmental Standards Systems. It will address the methodological challenges for impact assessment, e.g. in discussing whether certification can be regarded as intervention in forest management; in identifying appropriate counterfactuals; in attributing characteristics of the forest management to certification requirements; in finding a balance between environmental, social and economic reduced negative and achieved positive effects of forest management; and in generalizing findings in individual certified operations. Methods like the analysis of Corrective Action Requests from public certification reports and meta-analysis of independent researchers' papers, as well as the FSC Theory of Change and impact indicators, will be presented. The paper will also explain the concept of the multidisciplinary Value and Impact Analysis (VIA) Initiative, and summarize the recommendations emerging from this initiative to support FSC - and other ISEAL members - in making adequate, business-ready claims. This will be followed by a call for further systematic, meaningful research.

certification, impacts, evaluation, methodologies

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IUFRO17-1239 **Influences of the FSC certification process on forest governance in the Congo basin**

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Abstract: The Earth Summit in Rio de Janeiro had two ambivalent consequences for tropical forests. On the one hand, it contributed to promote new forest policies that were inspired by the paradigm of sustainable forest management. On the other hand, given the lack of consensus to establish an international treaty on forests, it prompted environmental NGOs to develop private systems of forest certification, like the Forest Stewardship Council (FSC). For 25 years, these two dynamics have been interacting at the international and national levels, while most assessments of the impacts of forest certification are done at the local level, and especially in and around logging concessions, at least in the Congo Basin. By contrast, this paper analyzes the influences of the debate and the implementation of the FSC standards on changes in forest governance at the national level for 15 years in Cameroon, Congo and Gabon.
Forest governance has not changed either regularly or identically in the three countries. However, a few observations are similar: in the 3 countries, the implementation of forest management plan remains unsatisfactory and the fight against corruption has not been effective. Conversely, the respondents indicate progress on the participation of stakeholders in the elaboration/implementation of public policy, better traceability of products and greater consideration for high conservation value ecosystems.
According to these interviewees, FSC certification has had a mixed influence on forest governance at the national level for the past 15 years. Overall, many elements of forest governance have experienced only marginal or no influence from the discussions and the implementation of FSC certification in the Congo Basin. We describe the historical reasons for this low impact and detail how FSC succeed in influencing a few key aspects of sustainable forest management.

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IUFRO17-3683 **A simple and effective methodology to show FSC impact on conservation**

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Abstract: For a certification scheme relying on stakeholder engagement it is crucial to show impact of certification interventions on conservation to attract NGOs as well as forest managers. Our method is based on a literature study where the conservation considerations of the national FSC standard are compared with legislation. The differences are quantified and the contribution of certification to conservation is analyzed using scientific literature. From impact studies in Sweden, Finland, Latvia and Estonia we can draw some conclusions. Firstly, the FSC-requirements that stand out as contributors to conservation are either unique for FSC, i.e. not mentioned in the national legislation, or where FSC requires a much higher level. Secondly, certification can also have target oriented requirements, while legislation is more about strict protection or considerations taken at harvesting. Thirdly, some requirements are difficult to attribute to certification interventions because they are hard to quantify or research is lacking. Finally, law enforcement, respectively recommendations that have been turned into hard requirements, were identified as important contributions of certification. Setting up national reference groups to review the analysis has proved crucial for securing the national relevance of the study. Such comparative studies give a sound overview of the certification impact with a rather low investment, and it can easily be repeated in any country with FSC certification.

FSC, forest certification, impact, conservation

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IUFRO17-3187 **Do certified private forest plantations increase the provision of and access to social services for local communities?**

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Abstract: This study examines the impacts of sustainable forestry operations (FSC certified) as compared to conventionally-managed, government owned forest operations on the access of local households to healthcare, schools and physical infrastructure (roads, bridges). We present the results of structured interviews with 338 households in Tanzania, randomly selected from two villages located near privately owned certified plantations and from two villages near a state owned non-certified plantation, and of focus group discussions held in the study villages. We employ a logistic regression model to quantitatively investigate the relation between the plantations and their perceived impacts on the number of health care facilities, schools, number of children going to school and the length and condition of roads and bridges in the villages. We use qualitative analysis to investigate community perceptions, based on the focus group discussions, about the impacts of the plantations and to triangulate with the results of the regression model. The results are pertinent to current concerns about the growth and sustainability of modern large-scale forest operations in developing countries and can inform debates about mitigating the negative and enhancing the positive impacts of changes from customarily governed common lands to concession managed or owned planted forests.

Certification, Sustainable forestry operations

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IUFRO17-2773 **Impacts of forest tenure and management regimes on forest cover change - lessons learned from a pan-tropical evaluation**

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Abstract: Forest tenure and forest management regimes - including certification and community-based management - are considered key policy levers for promoting sustainable management of forest resources. However, to date very little and often non-comparable evidence has been generated on the effectiveness of alternative regimes, especially in tropical developing countries. Global geospatial data on forest-cover change have lowered the costs of rigorous impact analyses of introducing new regimes. Yet, barriers remain to research that supports decision-making by governments, communities, certification systems, and actors along the supply chain. First, the field of impact evaluation is highly technical and rapidly evolving, making it difficult for practitioners to understand and adopt the data and methods that provide rigorous evidence. Second, there is a large disconnect between the growing set of sophisticated academic analyses and the information needed by actors to effect change on the ground.

To help overcome these barriers, we will share lessons learned from a pan-tropical evaluation of the impacts of common forest tenure and management regimes on forest cover change. This pan-tropical research builds on individual co-authors' previous research on the topic across several tropical countries to provide consistent evidence on the impacts of logging concessions, FSC certification, and local and indigenous community-based management, relative to formal protected areas and unmanaged, in terms of forest cover, forest configuration, and carbon emissions. We use the results to test empirically the role of geographic and socio-economic factors in determining the effectiveness of interventions in meta-analysis models. A collaboration of academics and conservation practitioners, this work will provide guidance on how to conduct and interpret impact evaluations in the tropical forest management context, with a focus on the use of geospatial datasets.

impact evaluation, management, tenure, forest loss

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IUFRO17-4050 **Demonstrating impacts from certifying ecosystem services: Challenges and solutions**

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Abstract: During the past two decades the value of various benefits forests provide has been increasingly recognized. The increased recognition has been combined with the need to ensure effective governance of the provision ecosystem services (ES). Alongside public regulation private standards to certify initiatives that provide ecosystem services have emerged. These range from standards focused on carbon accounting for obtaining carbon credits to initiatives to certify management of protected areas. Forest Stewardship Council (FSC) has been developing new tools dedicated to ecosystem services to deliver additional monetary and non-monetary benefits for certificate holders and communities. It has been testing its approach in a pilot project (ForCES) in Nepal, Vietnam, Indonesia, and Chile.

One of the key elements in FSC's approach is inclusion of criteria to demonstrate impacts and thus, making the connection between claims that certificate holder makes and management activities transparent and scientifically credible. Here we discuss the challenges linked to demonstration of impacts in certifying ecosystem services and solutions to them. We draw from our experience in developing new FSC ES tools and implementing them as part of forest certification in both community and company controlled sites. We also discuss issues related to verifying both impacts and claims that are linked to them.

governance, voluntary standards, sustainability

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IUFRO17-3088 **Influence of corporate responsibility on financial return in planted forests: case studies from South East Asia and Africa**

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Abstract: Investments in planted forests in emerging markets are increasing and investors are looking for Sustainable and Responsible Investments (SRI) to integrate Environmental, Social And Governance (ESG) into the investment process.
This study presents an ESG Risk Assessment protocol tested in 12 case studies of investments in planted forests evenly distributed between Uganda, Cambodia and Vietnam.

The ESG Risk Assessment allows to identify the most important 25 issues for investments and reveals that existent instruments for SRI are often focusing on issues that on-the-ground are not the major risk sources. This is the case of "Third party certification" and "High Conservation Value Forests" (HCVFs). Few exemptions where SRI tools are properly identifying the major risks are "Tenure rights", "Health and safety of workers" and "Social impact assessment". Climate change impacts, long term financial sustainability, poverty reduction and encroachment are ranked as the most dangerous sources of risk across the 12 case studies.

SRI tools are positively influencing the risk mitigation of investments in planted forests, accounting for a percentage of risk mitigation that ranges from 34 till 60%. FSC certification was often reported by projects' stakeholders as a key instrument to mitigate risk of investments in planted forests.

investments, planted forests, risk, sustainability

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IUFRO17-2022 **Multipurpose forestry - an adaptive system for the future?**

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Abstract: The demand of society for ecosystem services such as protection of soil fertility, water quality, biodiversity, recreation, adaptation to climate change and carbon sequestration is continuously growing. How can forest management best deliver the ecosystem services demanded by society today and in the future? The answer to this challenging question varies depending on the specific local conditions such as the state of the forest, the ownership, the ecological and economic situation, and the values and perception of society. In addition, enhanced scientific knowledge, practical experience, and mentality of people may alter the values and perceptions. Ecological and economic conditions change over time as well. Therefore, the adaptive capacity of the ecosystem providing varying services in a satisfactory way has to be high. Some of these services may be conflicting, others neutral or even synergistic. Finding the appropriate mix of ecosystem services for achieving the highest benefit for the society is an everlasting challenge. We observe world wide a segregation of forest ecosystems for different services such as production forests, protection forests but as well multipurpose forests where various goods and services are provided at the same time. In this presentation the different options of forest management are described and their advantages and disadvantages for fulfilling the needs of society in an uncertain future are discussed.

Multipurpose, ecosystem service, adaptive capacity

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IUFRO17-3543 **Economic and Life Cycle Analyses of Biomass Utilization for Bioenergy Products in the Northeastern United States**

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Abstract: A modeling process was developed to examine the economic and environmental benefits of utilizing energy crops for biofuels and bioproducts in the Northeastern United States. Three energy crops (hybrid willow, switchgrass and miscanthus) that can potentially grow on marginal agricultural land or abandoned mine land in the region were considered in the analytical process for the production of biofuels, biopower and pellet fuel. The supply chain components for both the economic analysis and life cycle modeling processes included feedstock establishment, harvest, transportation, storage, preprocessing, conversion, distribution and final usage of the bioenergy products. Sensitivity analysis was also conducted to assess the effects of energy crop yield, transportation distance, conversion rate, facility capacity and internal rate of return (IRR) on the production of bioenergy products. The required selling price (RSP) ranged from $7.7/GJ to $47.9/GJ while the production of biopower presented the highest RSP and pellet fuel had the lowest RSP. The results also indicated that bioenergy production using hybrid willow demonstrated lower RSP than the two perennial grass feedstocks. Pellet production presented the lowest greenhouse gas (GHG) emissions (less than 10 kg CO2 eq per 1,000 MJ) and fossil energy consumption (less than 150 MJ per 1,000 MJ). The production of biofuel resulted in the highest GHG emissions and followed by the biopower production. Sensitivity analysis indicated that IRR was the most sensitive factor to RSP and followed by conversion rate for biofuel and biopower productions. Conversion rate and transportation distance of feedstock presented a significant effect on environmental impacts during the production of the bioenergy products.

energy crops, bioproduct, marginal land, biomass

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IUFRO17-3633 **Simulating effects of Silvicultural treatments on selected forest goods and services - a case study in subtropical China**

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Abstract: Silvicultural treatments alter forest characteristics such as stand structure, tree species composition and developmental stage, which in turn influence the quality and quantity of goods and services a forest provides, such as wood production, carbon and biodiversity. In this paper, a forest growth simulator PICUS and cost-benefit analysis are applied to assess the effects of a range of silvicultural options of selected species *Pinus massoniana* and *Castanopsis hystrix* on timber production and carbon benefits in subtropical China. The results of the study can be applied to demonstrate how much the tree species composition and management activities affect the selected forest goods and services, and what management options to be selected for the forest owners or managers to maximize their benefits. A proposal of using such tools more often in forest planning processes to support the development of forest land use visions and policies is also presented.

Silvicultural option, valuation, subtropical China

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104 - Valuation of Multipurpose Forest Management Options under Changing Climate

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IUFRO17-336 **The spatial distribution of an economically important NWFPs-providing species, Juglans regia, in Arasbaran forests of Iran**

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Abstract: Understanding of the spatial distribution and economic value map gives information to selection of high value forested area for conservation. Main study objectives were to assess the density, spatial distribution and to provide economic value map of walnut (Juglans regia) in Arasbaran forests. These forests are one of biosphere reserve located in the northwest of Iran. Biological data were collected within 6484 ha of these forests using full field surveying method and UTM coordinates registration of this species. Spatial distribution of walnut was characterized by Ripley's K(r) function in ProgramitaJulio2006 program. Moreover, individual tree fruit yield of was measured using counting the number of fruits and weighting of them. Economic data were collected using interviews and semi-structured questionnaires from four villages.The annual economic value map was provided using Arc GIS 9.3 based on the potential profit from sustainable production capacity of walnut. Results showed that the dispersal area of walnut species was about 10 percent of studied forests area. Results showed that the total number of trees in the studied area was 682 trees. The average yield of each tree was 49 kg. The sustainable production capacity of this species in the study area was 27 thousand kg. About 35% (9525 kg) of this capacity was harvested by local people. The average derived income for each household was estimated to be 70 US dollars. The annual gross value of walnut was 35 and 43 US dollars per hectare and per tree, respectively. The gross value for this species varied from 0.2 to 1147 US dollars per ha in the different size of dispersal areas. Results from Ripley's K(r) function confirmed an aggregated spatial distribution. We found that the dispersal area of this species was mostly in humid valleys and Quercetum forest type. Intensive production and distribution of this species is useful to local people and managers to collecting, conservation, and ecological expansion.

spatial distribution, Economic value, production,

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IUFRO17-3125 **Playing games in forest based climate change mitigation**

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Abstract: REDD is an agreement aiming at reducing emissions from deforestation and degradation through provision of a market for carbon trading where village communities in developing countries may sell carbon stored in their adjoining forests and woodlands and governments or NGOs are willing to buy the stored carbon. This paper explores strategic interactions between the two actors. While reducing GHG emissions caused by deforestation is an objective for the buyers, the village community aims at maximizing net present value of income from all uses of land. Strategies of the village (seller) are comprised of a set of land-use decisions. These decisions deal with which forest and woodlands are deforested or degraded during the plan period. The profitability of different agricultural crops and employment opportunities for local people influence these decisions. Buyer's strategies include the choice of price (USD/tCO2) and the adopted reference level of deforestation. Strategies varied significantly in terms of effectiveness (tCO2) and efficiency (USD/tCO2). Using a bio-economic model and game theory for a village in Mvomero District, Tanzania, we showed that the choice of reference level is a major factor influencing villagers' strategy/response. If CO2-price is low, but last year's emission is the reference level, only forests with high biomass density will be preserved. In that case, REDD efficiency is high. If BAU emissions are the reference level, CO2-price must be higher to achieve further reductions. In that case, woodlands of low biomass density are also preserved, REDD effectiveness is high, but efficiency is low.

non-cooperative; Nash equilibrium; bargaining game

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98 - Biopriacy

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IUFRO17-1416 **Biopiracy in Turkey**

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Abstract: Ranking ninth on the European continent in terms of biodiversity, Turkey is among the richest countries in Europe and the Middle East. Each one of Turkey's seven distinct geographical regions possesses its own characteristic climate, flora and fauna, and the country is intersected by three most ecological regions of the world.

Turkey also has a wealth of animal species comprising nearly 120 mammals, more than 400 birds, nearly 130 reptiles, and nearly 400 fish. Turkey's distinct and varied geography ensures a high level of endemism and genetic diversity. Turkey is also located at the junction of two important Vavilovoyan gene centers: those of the Mediterranean and Near East. Moreover, Turkey itself has five different "micro-gene centers."

Due to its high level of endemism and genetic diversity, Turkey is also a center of attraction in terms of genetic resources. This raises the issue of biopiracy, which is a significant problem that threatens both the biodiversity and the economic future of the country. With this study, we will review and examine the case examples, legal implications for combatting biopiracy; national legal regulations on the subject; legal and administrative sanctions against biopiracy and their effectiveness.

Biodiversity, genetic resources, regulations

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IUFRO17-2597 **The Loss of Rare Plant Genetic Resources: A Case Study on Orchids in Yunnan Province in China**

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Abstract: The loss of local rare plant genetic resources has got the attention of the world. It is not only a matter of intellectual property rights, but also an issue about the stability of local biodiversity and ecosystem. Because forced by huge commercial interests, some local rare plant genetic resources are suffering serious loss and destruction. Using snowball sampling and participatory survey method, the local communities, middleman, dealer, law-enforcing department, resources management department, industry associations, companies, scientists and other stakeholders and the loss of orchid genetic resources in Yunnan province were investigated, and the findings were deep analyzed and discussed with the theory of Neoinstitutional Economics. The findings showed that a large amount of local orchid genetic resources lost overseas, accounting for 80% of that of China, and mainly lost to developed countries with various hidden ways. In addition, because of having huge economic interests, the local orchid genetic resources and their habitat are destructed seriously. Three main reasons might be illustrated in this research. Firstly, under the current Chinese collective forest tenure arrangement, the property of local rare wild animals and plants genetic resources is not clear, and it is cost highly to define them clearly. Secondly, it is costly to enforce laws, while the illegal cost is relatively lower. Thirdly, the social value orientation of orchids has transited from the traditional culture value to economic value, which has aggravated the illegal collection of orchid genetic resources and the destruction of their habitat. The paper proposes some suggestions for combating the loss of local rare plant genetic resources from three aspects, including organization development, ability development and institutional development.

genetic resources; orchids; property rights; China

KG I - 1009 (Uni Freiburg)

IUFRO17-1437 **Agroforestry research in Central Europe: Past, present and future**

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Abstract: Agroforestry is an ancient land use practice in Europe. The probably enormous former diversity of local agro-ecological systems combining cultivation of crops or animal breeding with tree cover is today assumed upon from their wide relic spatial distribution. These land uses are however on decline in the temperate regions. The decline of these mixed systems in Europe, usually linked with cessation of traditional management, e.g. grazing, or removal of trees from fields, meadows and pastures, is connected with mechanization, demand for more productive, less labour intensive land uses, bigger, simpler and monoculture plantations and other factors.
As they become scarce, the natural and cultural values of these mixed systems are being recognized on the European and global political level. Agroforestry is hoped to help solve some of the painful rural local, regional and even global problems - farm profitability and the stability of production, animal welfare, rural countryside depopulation, eutrophication of waters, biodiversity loss or at last but not least climate impact.
Unfortunately continental Central European agroforestry is from historical and biogeographical point of view less researched compared with Mediterranean, Atlantic or Boreal examples. Taking this into account panel will address this information gap by summarizing the agroforestry research traditions and their current status in Central European countries. That would allow international comparison with Mediterranean, Scandinavian, Alpine or geographically most close historical and ethnographic parallels and eventually the theoretical and practical advocacy of conservation or restoration of agroforestry plots and their management in this region.

agroforestry, central Europe, history, research

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162 - Agroforestry research in Central Europe: Past, present and future

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IUFRO17-3423 **Promoting and hindering factors for the implementation of agroforestry systems in Germany**

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Abstract: Agroforestry systems are appraised as ecologically and economically beneficiary within the German discourse about agriculture. Nevertheless, agroforestry systems are seldom adopted by farmers and viewed with skepticism by administration and the public. Therefore, the Innovation Group AUFWERTEN (Agroforestry for Environmental Services, Energy Production and Added Value funded by the German Federal Ministry of Education and Research) analyzes the factors which promote or hinder the adoption of these innovative land-use concepts. On the basis of the concept of regional governance we actively influence and analyze the following elements of regional governance in the study area of Finsterwalde, Brandenburg:
-Social Network Analysis (SNA);
-Intersectoral coordination;
-Participation of experts and lay people;
-Multi-level coordination;
The emerged network combines actors from communities, enterprises within the energy market and farmers. Also, the AUFWERTEN-project team is temporal member of this network. While some innovative farmers already start to plant short-rotation-strips primarily to prevent wind erosion, the majority of the farmers are still reluctant to change their management strategies. Within the started participation process it became obvious that the maintenance of shelter belts which were planted during the communist era is a central issue for several actors. Here problems of inter-sectoral and multi-level coordination have to be solved. Within the Common Agricultural Policy (CAP) and the nature protection regulations the use of such windbreaks are highly regulated. Still, there is a pressing need for future management solutions considering agroforestry systems already present and degrading. On the other hand the expectations are high on newly agroforestry systems that could ideally benefit the farmers, should lie in the public interest, enrich the landscape aesthetically and contribute to farmland biodiversity.

regional governance, inter-sectoral coordination

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IUFRO17-3503 **To implement or not to implement agroforestry practices: An Analytic Network Process approach for European biogeographical regions**

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(1) European Forest Institute , Joensuu, Finland; (2) Universitat Politècnica de València, Valencia , Spain; (3) Cranfield University, Cranfield , United Kingdom; (4) Istituto di Biologia Agroambientale e Forestale , Porano, Italy; (5) University of West Hungary, Sopron, Hungary; (6) Hungary Centre for Ecological Research, Hungarian Academy of Sciences, Tihany, Hungary

Abstract: In order to shed light on the factors which frame agroforestry practices in Europe, a total of five Analytic Network Process (ANP) models were developed to reflect farm management scenarios for five European biogeographical regions, in which a typical farm for each region could alter its management by implementing different types of agroforestry practices. The ANP models were developed in a participatory manner through a series of questionnaires and two workshops with a total of 18 experts in agroforestry. Each of the models was associated with different benefits, costs, opportunities and risks, with a total of 40 criteria. Each model had five alternatives which could be implemented. These were: i) High natural and cultural value agroforestry systems; ii) Agroforestry with high value trees; iii) Agroforestry for arable systems; iv) Agroforestry for livestock systems, and; v) No agroforestry. In general, High natural and cultural value agroforestry systems were the preferred management alternative, whereas livestock agroforestry systems were preferred in the model for Pannonian region. The ANP model for the Atlantic region differed from the other regions, with very low priority of high value tree and arable agroforestry systems. The No agroforestry alternative was a viable option in the models representing Atlantic and Boreal region due its low costs and risks. Compared to the No agroforestry alternative, agroforestry practices were associated with high environmental benefits such as lower input of pesticides, improved water quality and improved flood regulation. Other important benefits were lower business risks due to diversification and family tradition. Higher employment in agroforestry systems was seen as an important opportunity, but it also entails pronounced labour costs. Lack of subsidies was seen as the greatest risks. An understanding of these connections will be important when designing new, or updating existing, agricultural supportive policies.

Analytic Network Process, agroforestry

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158 - Publishing forest and wood science: Challenges for editors and publishers

KG I - 1228 (Uni Freiburg)

IUFRO17-3205 **Quo vadis, forestry journal? The identity and scope of scholarly forestry journals in the era of megajournals and IoT**

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Abstract: The list of forestry journals is long, and in several cases the identity and scope of the journals overlap at least partially. In the era of megajournals and the ever more pervasive internet, and as the demand for cross-disciplinary approaches increases also in forest research, is there need for all these journals? Would a "Forestry ONE" be the most rational solution, or would it lead to reduced scientific quality or impact of the research? Will cross-disciplinarity offer a new niche for forestry journals? Should a journal aim for a broader scope, or instead seek to specialize? Or, does it matter where the research is published, when the most important thing might be that the publication can be reached anytime and anywhere? Based on discussions in the meeting of IUFRO Working Party 9.01.06 "Forest Science Publishing" in Helsinki, 2015, the background and potential consequences of these and related questions are explored. Literature information is used to capture plausible trends in the development of the identity and scope of scholarly journals. The differences and similarities in forestry journal's identity and scope are visualized, and a comparison is made between metrics of forestry studies published in a traditional journal vs. in a megajournal.

Forestry journals, scholarly publishing

KG I - 1228 (Uni Freiburg)

IUFRO17-1582 **Coordinating multiple avenues of dissemination in today's technological environment: Extracting value from legacy publications**

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(1) Society of American Foresters, Flagstaff, Arizona, United States

Abstract: This presentation will deal with using multiple avenues of knowledge dissemination to transfer the same packet of information to different consumers, to new consumers, and/or to reinforce the education of the same consumers. Part of this process is evaluating whether the prior-published knowledge is still of value to consumers. Certain disciplines or topics are more amenable to revisiting later than are others. There is also a value to the knowledge provider, where the information provided by the producer is further ingrained into the body of the knowledge of the field or the reputation of the journal is enhanced by reinforcing in the minds of knowledge consumers the message in the article or other format. Knowledge providers can also benefit where revenues might be enhanced due to being able to "sell" the same information more than once. Examples will be provided from one professional society and its various knowledge-transfer outlets.

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IUFRO17-2263 **Open science and the quality of science**

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Abstract: Open science is a much wider concept than just free access to the results of science; it is also essential for assuring the quality of scientific research. This aspect of openness has not received wide attention in the forest research community yet it is under an intensive discussion in some other fields of study, in which reproducibility of research results has turned out to be poor. Two main factors for the non-reproducibility problem are sloppy reporting of research and the lack of data and methods transparency. Thus, opening of data is important not only for reuse of them but also for revising the validity of published results. Direct repetition of forest research is often impossible because of the long time needed to conduct research on long-lived forests under changing and variable environmental conditions. This adds emphasis to the importance of opening the data. I will discuss the application of the transparency standards of the Center for Open Science from a journal editor's viewpoint. Forestry journals should start to request the opening of data as a condition for publication of a manuscript. During a transition period of 2-3 year, an encouragement to open the data in author instructions would be acceptable.

open data; reproducibility; scientific publication

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158 - Publishing forest and wood science: Challenges for editors and publishers

KG I - 1228 (Uni Freiburg)

IUFRO17-2198 **Contribution of Forest Science journals to open data: a few examples and some issues.**

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(1) Inra, Champenoux, France

Abstract: In Forest Science, there is a trend towards Open data. Open data are made available to a broader audience in support of the claims in a published paper or for further use in meta-analyses or to address new research questions. Producing data sets, making them available in open repositories as citeable scientific productions with a Digital Object Identifier (DOI), is probably the best way to fully value a research project. Indeed, results may be disseminated not only as research papers, but also as well-structured and identified data sets. Funding agencies provide strong incentives to disseminate and provide access to data for a broader community.
Journals of Forest Science may actively contribute to this trend and:
1.Publish data papers, that is short papers presenting a data set, and containing a link to metadata enabling the reuse of the data set. The data set itself should be available in a repository with a DOI. This is a nice way to attract attention on data sets for re-use and further valuation;
2.Inciting authors to produce the data sets in support to any published paper, under similar conditions than above.
3.Describing explicitly the Journal's policy towards open data and what is expected from the authors in this respect.
Surprisingly, authors and researchers are sometimes still reluctant to provide access to their data. In certain areas nevertheless, it is already common practice (in genomics, greenhouse gas monitoring,forest inventories, ...). Reasons for this reluctance are not easy to identify and probably quite variable. Our Journals may contribute efficiently to the effort towards open data by convincing authors (and researchers) that open data bring an added value which may be of benefit to those who produced the data set as well as to the broader research community.
We will show some initiatives that journals may develop in support of the open data trend, and discuss opportunities and issues of this trend for our journals in Forest Science.

open data; open science, editorial policy

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IUFRO17-3932 **Publishing survey-based research in forestry journals**

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Abstract: Our research was focused on publishing survey-based research in forestry journals. In social sciences surveys are most commonly applied approach, primarily because of generalizability and efficiency aspects. We were interested in the quantity and quality of survey-based research published in forestry journals so as how journal editors perceive it.

In the period of ten years (2005-2014) the 20 forest science journals (15 from the SCI-list and 5 none-SCI journals) published almost 10 000 papers (9372). Out of it, 304 papers were survey-based. If these articles are taken as a proxy for the conduct of survey-based research in forest science then in average 3.2% was survey-based (a maximum per journal contribution of 22%). Out of different types of survey-based research, explanatory one is becoming ever more essential, and this is expected to continue also in the future. After the framework of 16 items was applied to all types of 304 survey-based papers, for the purpose of examining their methodological rigor, we found that for half of these items the methodology could have been more carefully applied (this holds true for an average, individual manuscripts differed sometimes considerably among each other). Also a short survey conducted in 2014 among editors of the same 20 journals (self-administered e-mail questionnaire, 75% response rate) showed skepticism about some aspects of survey-based research, like generalization of results. Journal editors were evenly split in their views "if survey research should be considered equal or complementary to other types of original research" - 40% hold the view that no difference should be made and another 40% think that survey research should in the first place play a complementary role. Most editors reported the same review process for survey-based articles as for all others. In two journals articles with the survey-based content are screened more rigorously and in two journals their publishing is generally discouraged.

survey-based research, forestry, publishing

KG I - 1228 (Uni Freiburg)

IUFRO17-3871 **Science to Sustain the World's Forest: publishing issues in Forest Ecology and Management**

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(1) Northern Arizona University, Forest Ecology and Management, Fort Collins, United States; (2) Elsevier, München, Germany

Abstract: The role of scientific journals is evolving rapidly in the 21st Century, as expectations of authors, colleagues, and societies develop and respond to advances in information technology. The traditional product from publishers was the journal itself, functioning simply as an output for the paper created by authors and honed by peer review. Journals are now developing stronger interactions with authors and clients. Some features are designed to enhance the quality of science in the development of experiments, including an active role in helping new scientists develop better projects. Other features are more substantial, including opportunities for authors to network, and to develop data repositories for open access. Our presentation touches on some of these general topics, and provides specific examples from Elsevier's evolving systems.

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IUFRO17-2066 **The International Journal of Forest Engineering: Future Challenges and Opportunities of a Well-Established Journal within the Applied Sciences**

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Abstract: The International Journal of Forest Engineering (IJFE) has provided a forum for the forest engineering community to report the results of their research and to disseminate findings to industry for more than 25 years. The journal emerged in response to the academic development within the field, with a need provide a forum for researchers to publish their results as scientific papers in an international, peer-reviewed journal. Much has happened since the start, both in terms of how forest operations are conducted, research focus and the conditions for the researcher's publishing in the journal. The case of IJFE is believed to be a typical example of the historical, current and future challenges of well-established scientific journals which have a natural and important role in long-standing, but yet small, applied research fields. Many of the challenges are found in the expectations of a homogeneous landscape of scientific publishing, with populistic and large research fields setting the norms.

Based on a survey of editorial board members, reviewers, and contributing authors, the journal's future challenges are discussed, with a special focus on how the current academic rewards system, with a base in various journal ranking systems, influence journals like IJFE.

Applied research, peer review, impact factor

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175 - Research approaches to forest policy and governance analysis

KG I - 1224 (Uni Freiburg)

IUFRO17-2994 **Institutional forest policy analysis: topics and trends**

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(1) Wageningen University and Research Centre (WUR), Forest and Nature Conservation Policy Group, Wageningen, Netherlands

Abstract: Institutional approaches to forest policy analysis originate from various sources: (1) institutional policy analysis as a critical response to rational policy models; (2) institutional economics for understanding the governance of common pool resources, as a response to the tragedy of the commons metaphor; (3) critical institutionalism as a response to institutional economics; and (4) international regime theory for analysing (a lack of) international regulation of forests. This oral presentation will shortly go into these institutional schools and will touch upon their developments, merits and drawbacks. Moreover, these theories will be assessed in light of future challenges, like climate change, the new geopolitics and the bio-based economy, posing challenges of dynamics, complexity and uncertainty for institutional theory. Do these theories need to (radically) change in order to be able to address these challenges or do they have enough descriptive, explanatory and predictive power to do so? Or do we need to go beyond institutional theory and learn from others?

KG I - 1224 (Uni Freiburg)

IUFRO17-3163 **Discourse analysis in forest policy research**

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Abstract: With the 'argumentative' turn in political sciences, the relevance of discourse analysis for policy making has become very popular. Discourse analysis is neither a method nor one theory but a strand of litertaure focusing on language, text, ideas, concepts, narratives and/or communication, and on how these are related to governance. The common assumption is that words, stories and arguments matter in politics. Three major schools of discourse analysis can be differentiated: (i) the linguistic discourse analysis, (ii) post-strucuralist discourse analysis mainly influenced by the work of Foucault and (iii) discourse analysis basing on the concept of communicative action as represented by Habermas. In particular the two latter have been increasingly used as a theoretical framework of (empirical) studies in the area of forest policy. The main aim of this paper is to provide a short overview about approaches of discourse theory and exemplify how these have been applied in forest policy research to identify what can be gained from these approaches.

Discourse analysis, forest policy, governance

KG I - 1224 (Uni Freiburg)

IUFRO17-3329 **A practice based approach to forest policy and governance**

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Abstract: A practice based approach to forest policy studies is relatively new in the field. The approach seeks to bring ideas from various neighbouring fields of natural resource management, organisation studies, interpretive policy analysis (IPA), and science and technology studies (STS) to bear on the specificities of forest governance. For example, it takes the idea of informal institutions work on common pool resource management and adds the notion of logics of practice to understand routinized behaviours. Or, it applies the concept of situated agency used in policy analysis of British governance and applies it to how policy makers can exert agency to deal with nature restoration in floodplain areas. It may also use insights from STS to discuss how our descriptions and representations of forest cover through remote sensing change both forest policy and forest landscapes across the globe as they become performative of their own descriptions. The presentation will highlight these points and more, discussing how practice theory - as an eclectic assembly of ideas rooted in social theory - can offer fresh understandings of the new realities that forest governance encounters in an age where all is connected.

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IUFRO17-2696 **The empirical-analytical approach to forest policy analysis**

Giessen, L.* (1)

(1) Forest Policy, Göttingen, Germany

Abstract: According to Kleinschmit, Böcher and Giessen(2016) the empirical-analytical approach is anchored in positivism, a philosophical position in science, emphasizing empirical data and scientific methods. A basic assumption of positivism is that society, and distinct groups within it, operate according to general patterns, similar and in analogy to (other) natural phenomena which are following natural laws. Such patterns are based on factors (variables), which are in a causal relation to each other. Analytical science would detect such dependent and independent variables through (i) hypotheses on their assumed causal relations,(ii) their empirical proof or falsification, followed by (iii) a refinement of the hypotheses and further development of the theories from which they were derived. Consequently, these patterns are empirically detectable by researchers through rigorous qualitative as well as quantitative methods.

forest governance methodologies methods variables

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203 - Forests for sustainable development: shifting discourses and approaches

KG I - 1098 (Uni Freiburg)

IUFRO17-197 **Forests for Sustainable Development: A process approach to forest sector contributions to the UN 2030 Agenda for Sustainable Development**

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Abstract: The paper takes off from the point stressed in 1987 when the concept of sustainable development was introduced into the UN as not a fixed state of harmony, but rather a process of change. A 'sustainable development as process' (SDAP) approach for the forest sector is described, and three main principles are discussed: (1) create stronger synergies and linkages: between goals, among nations, and with the SD processes operating within the other sectors that affect and are affected by the forest sector; (2) maintain continuity in the sector by building future forest development processes as part of an evolution of the continuum from past to present and on into the future; (3) pay equal attention to processes that are designed to avoid unsustainable development and processes designed to promote sustainable development. The conclusion is that forest sector processes need to evolve to meet the ever-changing global challenges facing all sectors in the context of the new UN 2030 Agenda for Sustainable Development. Much stronger, effective linkages between processes are needed within the sector and with other sectors locally and across countries. The paper discusses how the forest sector best can contribute to the success of the new UN Agenda using a SDAP approach.

SD, UN 2030 Agenda , SFM, inter-sectoral linkages

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IUFRO17-70 **REDD+ politics in the media: A case study from Vietnam**

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Abstract: Reducing emissions from deforestation and degradation (REDD+) is an international effort to create financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from land uses. Vietnam is engaged in the international REDD+ debate and is a partner to numerous multi- and bilateral agreements. Different actors have diverse interests in the REDD+ agenda, and in Vietnam, even though an authoritarian state, different views exist on what REDD+ should achieve. Through the analysis of media articles this study intends to understand how public debates on REDD+ are framed in the Vietnamese policy domain and how actors use the media to promote their interests. Reporting about a diversity of actors and interests, in particular related to expressions of equity concerns in media frames could reflect a growing inclusive political space. Our findings show that while state actors dominate REDD+ media frames, some limited space is present for non-state actors' interests, but equity issue discussed, unlike in other countries, still reflect predominantly state mediated concerns. However, these two key findings could indicate some prospects for the uptake of non-state actors including domestic businesses and international organisations in the Vietnamese REDD+ experiment and a move away from entirely state-controlled media, but caution is still required due to the limitations these findings come with.

REDD+, climate change, discourse, Vietnam

KG I - 1098 (Uni Freiburg)

IUFRO17-3396 **Exploring Illegal logging narratives accross the globe**

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Abstract: In the last decade illegal logging has triggered the attention of policy makers and scholars of international forest governance. The issue is multifaceted, involving aspects of social and environmental sustainability, development, trade, access to markets and competitiveness. A vivid academic debate has resulted, exploring the nexus between markets and trade on one hand, and environmental and social sustainability on the other. The purpose of this presentation is systematically assess the international policy discourse on illegal logging and legality verification policies in different regions of the world, drawing on the concept of policy narratives. The presentation will build upon a multi-author paper which analyses and compares policy narratives in Australia, Cambodia, China, the EU, Indonesia, Peru and the US. The analysis is grounded on a rich empirical basis consisting of 260 interviews conducted by various researchers, numerous conversations with practitioners, policy documents and a media analysis. We find striking differences across the globe in narratives about illegal logging and legality verification and conclude that these need to be considered when assessing the support for, and the current and potential effects of, the emerging legality verification regime.

forest governance, environmental governance

All Division 9 (Forest Policy and Economics) Meeting

203 - Forests for sustainable development: shifting discourses and approaches

KG I - 1098 (Uni Freiburg)

IUFRO17-792 **Forestry development priorities in Finnish national forest programmes**

Katila, P.* (1)

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Abstract: National forest programme (NFP) is a comprehensive national level forest governance model and overarching strategy to guide forestry development towards sustainability. Focusing on Finnish NFPs this study aimed to uncover the possible sifts in the national level forestry development priorities between late 1990's and the present. Following Carol Bacchi's policy analysis framework that focuses on problematisations, the study concentrated on the framing of the societal problems or situations that the NFPs were aimed to address as well as the justifications of the programmes and the proposed solutions. The problematisations in the Finnish NFPs have mainly focused on economic sustainability, especially increasing the use of wood, profitability and competitiveness of forest-based industries and expanding and diversifying forest-based business and entrepreneurship. Ecological and social sustainability related issues have been included, but have generally remained secondary concerns. Economic sustainability has been seen to provide the foundations for ecological and social sustainability and increasing welfare.

policy analysis, problematisation, framing, NFP

KG I - 1098 (Uni Freiburg)

IUFRO17-3622 **Assessing the Impacts of Environmental Aid: Case Study on American and German Assistance Projects in Ghana**

Foster, M.* (1)

(1) Yale University, New Haven, United States

Abstract: International development aid organizations, with ample financial and technical resources, are well positioned to assist and reinforce domestic environmental stewardship efforts, and over the last few decades, international agencies have channeled billions of dollars into environmentally focused projects in developing countries. Scholars in the fields of natural resources and the environment, political science, and economics as well as practitioners have engaged in debates about the effectiveness of international aid in developing countries and about the optimal ways in which to administer aid across countries. Studies have reached conflicting results around the effectiveness of international aid projects at addressing the environmental problems they intend to, and many studies have tended to "blackbox" the complex processes linking aid flows to project outcomes and longer term institutional policy changes. In this paper, I attempt to illuminate these processes with a case study on projects implemented by US and German development aid agencies in Ghana. This paper explores how international aid is operationalized, assesses the impacts of international aid on the environment, and examines how international aid shapes domestic policies fostering responsible environmental stewardship over time. Through insights gained from expert interviews and a review of policy documents, I hope to draw lessons about the opportunities and constraints emerging from the provision of aid, shedding light on the institutional arrangements that most effectively support achieving desired environmental outcomes and on how domestic governments may leverage international aid interventions to formulate and implement well-designed environmental policies.

aid, sustainable development, effectiveness

KG I - 1098 (Uni Freiburg)

IUFRO17-892 **Shifting global development discourses: Implications for forest-related development?**

Galloway, G.* (1)

(1) University of Florida, Gainesville, FL, United States

Abstract: This presentation will explore implications of shifting global development discourses for forest-related development. Generally speaking, forest-related development has two primary outcomes of interest: favor forest extent and condition and associated ecosystem services; and contribute in a positive fashion to livelihoods, income and poverty reduction. Sustainable forest management (SFM) seeks to achieve these outcomes in a parallel and synergistic fashion. Global development discourses, including the SDGs, often imply trade-offs that, for example, can favor economic at the expense of conservation objectives and vice versa. Here, drawing on a series of articles being developed for an upcoming special issue of a journal and other sources, focus will be placed on forest-relevant trade-offs that are embedded within and between these discourses. Measures which forestry actors are taking to adapt their strategies, agendas and operational activities in response to these discourses will be explored, as will evidence of impacts on forests, forest management and forest-related livelihoods. The presentation will end with an overview of insights and recommendations that emerge from this analysis that could potentially contribute to forest livelihoods and forest integrity or mitigate risks to them.

Development discourses; SDGs; SFM; Outcome impacts

All Division 9 (Forest Policy and Economics) Meeting

137 - How can we contribute to better information and more efficient communication among different fields

KG I - 1228 (Uni Freiburg)

IUFRO17-3291 **Historical and current trends in formal and informal knowledge transfer in the forestry profession**

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(1) Society of American Foresters, Flagstaff, Arizona, United States

Abstract: Knowledge transfer in the forest sciences was traditionally directed from the academy, which represented a source or surplus of knowledge, to the practitioner, who represented a consumer or sink of knowledge. The source determined the amount and type of knowledge that was generated and conveyed.. Such education moved to a more consumer-oriented model with the advent of formal extension education organizations, frequently centered on institutions of higher learning. Another educational progression was from the senior practitioners in an agency or department to the newly hired junior personnel. These linear transfer models have been at least partly replaced by a more multi-modal construct, where many individuals, organizations, or government agencies are both producers and consumers of knowledge. This construct in part reinforces evolving roles in decision-making about and public influence over natural resource management actions. In this presentation, I will outline effective knowledge transfer using different mediums of instruction, learning theory for adult professionals, and knowledge transfer effectiveness in a multi-decision maker world.

technology transfer, andragogy

KG I - 1228 (Uni Freiburg)

IUFRO17-2170 **Accelerating the delivery and adoption of applied science - Addressing Common Communication Challenges from across Continents**

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Abstract: The real benefit of applied research lies in some form of value addition for the end user. There are many factors which can influence the perception of value, and the ability or even willingness to use knowledge and technology from applied research. These include understanding of the user's needs and situation, as well as the appropriateness and relevance of the information generated and the tools used to transfer the knowledge. As stakeholder audiences become increasingly diverse in their objectives and interests, the need to show the value and benefit of applied research while also communicating scientific outcomes through peer-reviewed literature presents both challenges and opportunities. Case studies are used to highlight common communication challenges as well as opportunities across continents.

innovation; knowledge transfer; value addition

KG I - 1228 (Uni Freiburg)

IUFRO17-2957 **The future of forest terminology - between tradition and innovation**

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(1) Natural Resources Institute Finland (Luke), HELSINKI, Finland; (2) IUFRO HEADQUARTERS, Vienna, Austria

Abstract: The choice and use of appropriate and consistent terms and definitions are central to effective communication in science, management, and policy. The network of IUFRO experts has worked with various levels of forest terminology since its beginning and it has released several publications on terminology over the years, most recently in 2016. Some of the concepts and glossaries are available online, but mainly as static pdf-files or separate databases, such as SilvaTerm or the Global Forest Decimal Classification. Now it is time to start bringing these vast sources of information into the new millenium. More and more data are provided online and as linked online data. The content descriptions and metadata of these datasets should be (inter)linked as well. We suggest that the terminologies published by IUFRO should be linked or combined into a Forest Ontology. This ontology should have permanent identifiers for its concepts and these should be linked to other related online services and their concepts (such as AgroVoc). The ontology should be provided as a service which has Application Profile Interfaces which provide access and tools for linking or using the concepts and the multilingual terms connected to the concepts while creating descriptions to any forest related content online.

terminology;information systems;taxonomy;ontology

All Division 9 (Forest Policy and Economics) Meeting

137 - How can we contribute to better information and more efficient communication among different fields

KG I - 1228 (Uni Freiburg)

IUFRO17-2035 **Indicators as information tools: From reporting to assessing SFM**

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Abstract: Sustainable forest management has been at the centre of the forest policy discussion since the 1990s. At the United Nations Conference on Environment and Development in Rio 1992, indicators were broadly introduced and are in the meanwhile well accepted and broadly implemented tools for monitoring and reporting about sustainable development and subsequently sustainable forest management all over the world. Related forest reports are regularly published globally, regionally and in several countries also nationally.
Assessment of progress towards sustainable forest management is one of the functions of indicators of sustainable forest management, but has received less attention and development than other functions, such as monitoring, reporting and providing a framework for policy making and consensus formation.
There has been no consent on how to evaluate progress towards sustainable forest management, which necessarily involves a value statement on the desired direction of change, and respective targets and thresholds. This lack has hampered a more intensive use of C&I for SFM in evidence-based policy making and a clearer communication of SFM critical issues to the public
This paper captures approaches of MCPFE & UNECE/FAO (2007), FOREST EUROPE & UNECE/FAO (2011), UNECE-SEMAFOR (2016) for indicator based analysis and assessments of sustainability and and summarises future prospects of indicators becoming suitable and efficient communication tools.

indicators, information tool, assessment

KG I - 1228 (Uni Freiburg)

IUFRO17-1030 **The institutional barriers of forest information exchange in the European Union**

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Abstract: The notion of bioeconomy has gained significant importance in both science and policy over the last decade. It has placed new demands on the European forests as a source of renewable biomass, and has led to the onset of new forest-related policies at different levels and different sectors across Europe. In order for these policies to be effective and rational, there is a need for a collaborative environment and the exchange of forest information between policy actors and data providers. However, this exchange remains a significant challenge. Evidence suggests that policy makers rely on individual experience or other secondary sources of information. In this study, we explore critical barriers inhibiting forest information exchange and cooperation. Based on both, qualitative and quantitative methods, our study identifies critical barriers such as the inaccessibility of forest information, its poor reliability and quality as well as institutional (actor-centered)barriers that limit the extent of exchange, e.g. lack of trust, incentives, willingness, or interest to share forest information. The results offer also insights into the options of overcoming these barriers. Enabling policy environment and institutional reforms are needed to complement efforts to improve forest information exchange in the EU. The study concludes by articulating the gaps in understanding forest information exchange, which will help guide future research and contribute to the continued policy discussions on evidence-based and integrated policymaking.

forest information exchange

KG I - 1228 (Uni Freiburg)

IUFRO17-3209 **Information about and for private forest owners**

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Abstract: Private forest owners play a determinant role in sustaining forests for future generations. However, as society changes so do private forest owner objectives, attitudes to forests and behavior. Understanding the mechanisms of change requires systematic acquiring of information about the owners in addition to information on their forests. In current systems of data collection on private forests (e.g. forest inventories) rather little information on social aspects of private forest owners is being collected. In this presentation we give an overview of methods and approaches to collection of data on private forest owners in a forest inventory and the possibility to extend data collection with surveys. The analysis is based on the example of the Slovenia Forest Service forest inventory, data processing and the availability of the information for individual forest owners. We highlight the most important data on forests which foresters in the field need in order to ease decision making of different types of forest owners. We present some conventional and well-established methods suitable for forest practitioners which can help to better understand forest owner objectives, attitudes to forests and behavior, and we introduce some more scientifically advanced methods suitable for specific areas of private forest owner research. Furthermore we will demonstrate how this knowledge contributes to improved forest extension activities.

private forest owners; information exchange

All Division 9 (Forest Policy and Economics) Meeting

27 - Community forestry/ Co-management as a possible solution for forest governance and livelihood

KG I - 1139 (Uni Freiburg)

IUFRO17-2837 **The local reality of tenure security in forest communities**

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Abstract: There is wide consensus that providing forest communities with secure tenure is key to preventing deforestation. Yet, the literature also shows most tenure arrangements do not change the communities' rights to make decisions about their land and resources as they see fit. Communal land titles, which are often promoted by policymakers as part of REDD+ programs, for example, are also commonly used in projects to promote agricultural production in rural areas. This paper describes how forest communities react to newly introduced tenure arrangements, how these do, or do not, influence their behavior, when it comes to their land use decisions, and how ultimately this impacts on conservation and livelihood objectives. It shows that forest communities tend to adapt these tenure arrangements to the existing set of local dynamics and traditions, instead of to the conservation objectives for which they have been introduced. In addition, the findings indicate that local actors' economic and other interests strongly influence their reaction to new tenure arrangements, and ultimately impact on whether conservation goals are achieved. The conclusions are based on a study of 60 indigenous and mestizo communities in the province of Datem del Mara ñon, Peru, where since 2012, different tenure arrangements have been introduced in many these communities, including communal land titles, local conservation areas and local forests. We use both quantitative and qualitative research methods.

tenure, communities, REDD+, conservation

KG I - 1139 (Uni Freiburg)

IUFRO17-3473 **REDD+: A new layer in the Philippines' Community-Based Forest Management**

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(1) University of the Philippines Los Banos, Los Banos, Philippines; (2) The University of Tokyo, Tokyo, Japan

Abstract: Community-Based Forest Management (CBFM) is a three decade long decentralization approach to forest management in the Philippines. REDD+ as new initiative towards climate change mitigation is also envisioned to be placed in CBFM areas in the country. This paper explores the viability of placing REDD+ in CBFM areas in the Philippines. Specifically, the sustainable livelihood impacts of CBFM was examined as well as the most recent livelihood impacts of a REDD+ pilot demonstration project in Southern Leyte, Philippines. Despite livelihood capital assets improvement with CBFM, financial capital remained a challenge. The REDD+ pilot project activities brought very little improvement to livelihood capitals of the people organizations. But the key toward a more successful achievement of sustainable livelihood objectives in both CBFM and REDD+ is the employment of good forest governance principles. Hence, CBFMs role to local level REDD+ institutionalization will be defined by the existing forest governance system.

forest governance, sustainable livelihood

KG I - 1139 (Uni Freiburg)

IUFRO17-3872 **Forest Tenure Reform Implementation: Perspectives from National and Sub-national Government Officials in Multiple Settings**

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Abstract: Few studies have attempted to systematically document the conditions facing government agency in multiple settings in their efforts to implement tenure reform. This study generates insights into the underlying processes and factors that influence tenure reform implementation from the perspective of individual implementers in government agencies at national and sub-national levels in three countries: Indonesia, Peru and Uganda. These three countries introduced reforms in their forestry sectors in the late 1990s, which shifted greater rights and responsibilities to sub-national actors and local communities. Preliminary analysis of data generated from interviewing up to 90 government officials indicate that reform implementation has been effective or somewhat effective in protecting community rights to access, use, manage and benefit from forests. Main constraints to implementation are inadequate budgets and insufficient manpower to execute tenure-related activities. Divergent priorities between national and sub-national levels and changes in government that redistribute personnel are additional factors that hinder reform implementation. The main tenure needs facing communities include frequent conflicts related to unclear boundaries as well as illegal expansion of settlements and illegal timber harvesting. Paradoxically, most officials did not think it was their responsibility to resolve tenure-related conflicts. Overall, respondents agree that reforms are only partially implemented due to technical and institutional constraints such as inadequate budgets and staffing levels, which in turn influence the extent to which collaboration/coordination among actors can be achieved.

tenure, reform, policy, government, governance

All Division 9 (Forest Policy and Economics) Meeting

27 - Community forestry/ Co-management as a possible solution for forest governance and livelihood

KG I - 1139 (Uni Freiburg)

IUFRO17-3241 **Social forestry in Indonesia: two early-moving communities obtaining permits and long-term funding for managing their Village Forest and Customary Forest, securing their forest-dependent livelihoods**

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(1) Value for Nature, Oxford, United Kingdom; (2) Bogor Agricultural University, Daemeter Consulting, Bogor, Indonesia; (3) LTS International, Edinburgh, United Kingdom

Abstract: Two forest-dependent communities in Kalimantan are among the first to apply for governance of their forests under a new policy by the Indonesian government to allow communities to collectively manage 12.7 m ha of forests by 2020. One community applied for a Village Forest (Hutan Desa), the other for a Customary Forest (Hutan Adat) licence. The management rights that accompany these licences will allow the communities to formalize management plans; to address external threats, such as poaching, illegal logging, new and existing concessions for logging, oil palm and mining; to protect and strengthen forest-based livelihoods, including hunting, fishing, rattan handicrafts, honey gathering and timber supplies; and to develop new ones such as ecotourism. They will also allow ecosystem services certification for the protection of carbon stocks and biodiversity, thus potentially adding funding that strengthens the long-term sustainability of the forest and their use of it. This paper will describe the journey of these communities towards obtaining forest governance rights, including legal, institutional and governance barriers they face, and will analyse the sustainability safeguards the licenced community forest management provides vis- à-vis the common practice of forest governance in Indonesia.

community forest management, finance, livelihoods

All Division 9 (Forest Policy and Economics) Meeting

70 - Improved role of forests for people through favourable forest laws and environmental legislation

KG I - 1224 (Uni Freiburg)

IUFRO17-239 **Forestry and the principle of no net loss of biodiversity**

Pappila, M.* (1)

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Abstract: No net loss (NNL) of biodiversity is an emerging principle of environmental law, the importance of which has grown globally due to continuous loss of biodiversity. The principle includes the mitigation hierarchy (avoid, mitigate, restore, compensate). Within the EU, Natura 2000 legislation is the most comprehensive example of implementing this principle. There are many examples of implementing the NNL principle to construction projects in several EU countries. However, other environmental legislation does not implement the NNL principle as consistently which may enhance biodiversity loss.

NNL is most commonly related to projects that change the type of land use: e.g. from forest or pasture to industrial area. It seems more difficult to implement this principle to ongoing land use such as forestry or agriculture. I will analyse how Finnish legislation concerning forestry currently relates to the NNL principle and all four stages of it, and what are the main gaps in implementing it thoroughly. For the most part it is difficult to apply the NNL principle directly to forest felling, but there are certain rules where the mitigation hierarchy could be implemented more rigidly: e.g. rules concerning summer loggings and bird nesting. It seems that especially legislation concerning species protection could be improved in this respect.

Law, no net loss, biodiversity

KG I - 1224 (Uni Freiburg)

IUFRO17-1910 **Historical root causes for the conflicts between forest and nature protection legislation in Germany**

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Abstract: Current forest and nature protection laws can be interpreted as institutionalizations of historical discourses. For example, the Bavarian Forest Law includes elements of the liberal, the oeconomia naturae, and the forest function discourse. In the German Nature Protection Law, many different conservation concepts are mentioned which sometimes are even contradictory, e.g. concepts of the preservation of cultural landscapes vs. the concept of natural dynamics.
The goal of the contribution is to show that
1. especially the forest laws provide solutions for conflicts (e.g. the conflict about the exploitation of forests due to agricultural land-use, conflicts due to the imminent supply crisis of wood) which were manifest in the past. Regulations which forbid the devastation of forests and their soils inhibit the conservation of ecosystems which are dependent on poor soil conditions induced. The concept to increase forest cover by regulating deforestation but not natural afforestation of farmlands endangers the conservation of semi-natural grassland formations.
2. the discursive framing of current nature protection concepts increase the conflict potential between forestry and nature protection. With the example of the Douglas fir, it can be explained that the situation of a tree species which has some invasive potential but is nevertheless highly interesting for forestry actors is not foreseen within in invasive species discourse. Here, invasive species are seen as "enemies" which have to be eradicated.

Discourse analysis, wood shortage, invasaviness

KG I - 1224 (Uni Freiburg)

IUFRO17-2033 **Legal conditions of sustainable public access to forests**

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Abstract: Forest sector, except of production of raw wood material, provides also the possibility of access to forests for general public that shall be considered as a part of the ecosystem services. However, such possibility is limited by both the internal management conditions as well as by the external restrictions. These limitations are determined by the regulative state measures, forest policy conception, business environment, and principles accepted by the whole society. The effective public access to forests is thus affected by a number of factors - the most important ones being property rights in forestry, economic interests and preferences of forest enterprises, legal restrictions, social and environmental interests and preferences of the society. The objective of this paper is to analyse and examine the principles, history and current status of legal conditions of sustainable and effective public access to forests using the case of the Slovak Republic. The author also identifies legal institutes, factors and restrictions that affects the sustainable public access to forests. Considering this, special attention is devoted to property rights in forestry with respect to the forest owner and user relations and legal restrictions of the forest ecosystem services provision.

forests, general public, access to forest

KG I - 1224 (Uni Freiburg)

IUFRO17-2059 **Liabilities resulting from Public Access to Forests in Austria**

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(1) Forest Legal Consultant, Villach, Austria

Abstract: Amongst the multiple functions of forests for people, relevance of their public use for recreation is sharply increasing in countries like Austria where local people just like tourists spend more and more time in forests, involving in any sorts of recreational activities.
This paper analyzes recreation in Austrian forests and the issue of opening forests for public access, and based on that, issues of property rights in contradiction with the public use of forests. Fault liability in Austrian law in general, in forests specifically, as well as on ways and roads are analyzed and negative effects of unfavorable legislation combined with excessive lawsuits are demonstrated.

Austria, public use of forests, fault liability

All Division 9 (Forest Policy and Economics) Meeting

70 - Improved role of forests for people through favourable forest laws and environmental legislation

KG I - 1224 (Uni Freiburg)

IUFRO17-1723 **Local communities in forest legislation of selected South-East European countries**

Avdibegovic, M.* (1); Nonic, D. (2); Posavec, S. (3); Vuletic, D. (4); Delic, S. (1); Becirovic, D. (1); Maric, B. (1); Pezdevsek Malovrh, S. (5)

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Abstract: Due to the unprecedented scale of social, political and economical changes, forest policy and legislation in former Yugoslavian countries have changed considerably. Once, sharing the common legislative framework for forest management, Slovenia, Croatia, Serbia and Bosnia-Herzegovina nowadays have different social and economical realities. The complexity of international forest policy processes brought the new modes of forest governance, in which the role of national forest authorities is changed. The new political environment have mobilised new interest groups at the national level and some of them, such as local communities, become important actors of forest policy. This paper deals with the role of local communities in development of new forest legislation, particularly the distribution of economical benefits from public forest management and legally prescribed instruments to strengthen the position of local communities in forest management and planning. Through comparative overview of national forest legislation in these countries, the paper explores the evolution of relations between public forest administration, as traditionally the strongest actor of forest policy and forest-dependent communities, as an emerging interest group. Several impacts on environment, social development and economical growth of this "power redistribution" process, at the national and local level, will be also analyzed.

Forest legislation, local communities

Poster Exhibition Friday

202 - Eco-friendly harvesting operations in mountainous terrains

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1313 **Log chutes: simple, economical, and environmental friendly**

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Abstract: Logging operations on highland is apparent to be more expensive and complicated than logging operations on flat terrain. Furthermore, the environmental impacts logging on highland has great importance in planning logging operations. The aims of this study were to identify a suitable logging system into studied area and to examine the logging impacts. The impacts of three different timber extraction methods (man power, animal, and log chutes) were examined considering soil, saplings, and wildlife. The finding revealed that all cases the timber extraction did not have significant impact on soil moisture or bulk density. Only impact on soil surface could be found. As a consequence of logging operations disturbed wildlife habitat, the wildlife has migrated from studied area. No evidence was found on logging impact by applying of log chutes and animal extraction. While, the manual timber extraction contributed the greatest impact on soil surface. As a consequence of opened soil surface, erosion may simply occur. Thus manual timber extraction should be avoided when operating on highland. In conclusion, log chutes log chutes were the most suitable logging system under given circumstances. It requires low investment, short payback period, easy to find materials, save the energy, effective, and environmental friendly. However, chute is limited to downhill extraction and for short wood operation.

log chutes, impacts, soil, highland

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1057 **Seed germination and early field performance of Quercus robur and Pinus sylvestris seedlings under soil compaction conditions**

Cambi, M. (1); Mariotti, B. (1); Fabiano, F. (1); Maltoni, A. (1); Tani, A. (1); Marchi, E.* (1)

(1) University of Florence - GESAAF, Firenze, Italy

Abstract: Forest operation processes by heavy equipment induces severe soil stresses that may influence natural stand regeneration. However, there is a lack of information about relation between forest machine passes and tree regeneration and growth. The aim of the study was to determine the effects of soil compaction on seed germination and on the early growth and development of seedlings belonging to two of the most spread species in Europe, Quercus robur and Pinus sylvestris. The study was carried out in a field plot located in Italian Northern Apennine, where the soil developed on Lower Miocene-Oligocene sandstone and was classified as Dystric Cambisol. Three different compaction levels (control and slightly compacted and compacted by logging operations) were considered. In 3 randomized blocks, 375 seeds for each species were sowed in February-March 2017. Data on germination and seedlings height were collected about every 10 days during the first vegetative season. The morphological attributes of seedlings' shoot and root system were assessed by five destructive analyses during and at the end of the first vegetative season, in order to evaluate the soil compaction influence on biomass, dimensions and architecture. Data processing was focused to compare undisturbed condition with the different compaction level in order to highlight the potential constraint effect over the whole first vegetative season since germination. The poster presents the preliminary results including data collected in early summer 2017.

Soil compaction, forest logging

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3078 **Comparison of effect of establishing forest road network using reliability**

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Abstract: In a mountainous area forest road network which is easily cut by sediment disasters, it is not clear how to arrange an effective road network to improve reachability to the destination. Therefore, we investigated which arrangement is effective for improving reachability by simulation using reliability. The research sites were 4 - 8 compartment of the Shinshu University experimental forest. The point on the road closest to the center of gravity of each sub compartment from the landing of the exercise forest was set as the destination. In calculating the reliability, the passage probability of each route is assumed to be proportional to the extension of the route. The simulation assumes a case where a new route is opened from the end point of a branch line to connect to an existing road network and a case where a retaining wall is constructed in a part of a place where collapse occurred in 2011-2015. As a result, the product of the reliability to all destinations has greatly improved when the branch line is made a circulation route by opening a line. However, there was no significant change when the construction was made on a line that frequently passes the retaining wall. Therefore, it was suggested that development of connectivity of road network by opening new route rather than reinforcement of existing route is effective for improving reachability.

forest road,reachability analysis,Circulation road

Poster Exhibition Friday

202 - Eco-friendly harvesting operations in mountainous terrains

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2592 **Tree felling manipulator to address specific conditions of Japanese forestry**

SHIRAI, Y.* (1)

(1) Waseda, Faculty of Science and Engineering, Tokyo, Japan

Abstract: In Japan, many fatal accidents and severe injuries occur during tree felling operations. Furthermore, Japan's forests are precipitous, soft terrain, wet, humid and a low logging road density. The forestry machine must withstand such specific conditions of Japanese forestry. Based on these author's research results, a set of design requirements is established. Then the author has devised the tree felling manipulator TATSUMI that embodied ultimate simplicity in its shape and mechanism. This manipulator is compact and lightweight enough to be carried by a single worker. This machine takes mountable/dismountable chainsaws that are commonly available at forestry sites in Japan. The manipulator is composed of 4 degrees of freedom. To operate the manipulator, and they also developed a control system. A demonstration model was built, experimented on, evaluated for its performance. The TATSUMI1, 2nd, 3rd, 4th and 5th have been developed. The latest version 5th is particularly mentioned at this time. By the way, the amount of a subsidy for Japanese forestry has exceeded the lumber production by 80 billion yen in 2013. The author is challenging to revitalize Japanese forestry with the technical development.

Manipulator Felling Portable Mountain forest

Poster Exhibition Friday

3 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3686 **Harvester performance in thinning operations based on automatically recorded machine data combined with onboard video capturing**

Holzleitner, F.* (1); Obermayer, B. (1); Kanzian, C. (1)

(1) University of Natural Resources and Life Sciences, Vienna, Department of Forest- and Soil Sciences , Vienna, Austria

Abstract: Increasing demand for round wood of pulp and paper mills as wells as saw mills and for solid fuel combined with higher potential revenues enabling to carry out also fully mechanized thinning operations in young and small diameter stands which were untended over the last years.
Essential silvicultural treatments such as fully mechanized thinning operations in young stands having small mean diameters with rather low proportion of high quality saw logs were postponed within the last decades due to low or even negative profit margins. At the same time costs for tree marking within thinning operations which is normally done by a well-educated forester were saved or even handed over to the machine operator's decision. The selection of trees in fully mechanized thinning operations could be either done by the machine operator's decision during the harvesting process itself or by marking the trees which are going to be remaining or harvested before the harvesting operation starts.
The objectives of the study is to analyze harvesting performance in low diameter standard thinning operations including the effect of tree marking based on detailed process analysis using both automated recorded sensor data from the harvester and onboard video captured process data. Based on detailed cost analysis the effect of tree marking shall be investigated using the developed productivity model. Forest owners and entrepreneurs should be supported with costing models to assist their planning of future thinning operations.
A study site was divided before operation started in 48 plots each 20m wide and 25m long. At the site two different types of silvicultural treatments were applied. Half of the plots the trees selected for remaining or harvesting were marked. At the rest of the plots the driver had to decide himself during the working procedure from the cabin of the machine which trees to take.

productivity, thinning, machine data, tree marking

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2950 **The effect of a stand's tree volume variation on harvester productivity**

Nordfjell, T.* (1); Pettersson, J. (1); Lindroos, O. (1)

(1) Department of Forest Biomaterials and Technology, Swedish University of Agricultural Sciences, Umeå, Sweden

Abstract: It is a well-known fact that the work productivity of a harvester is positively correlated with the mean volume of harvested trees. This is valid up to tree-volumes close to the technical limitation for the given harvester. However, two stands with the same arithmetic mean tree-volume (MTV) can have substantial differences in tree volume distributions. Hence, the actual productivity might also differ substantially between the stands. Thus, the aim of the study was to evaluate the possible effect of the tree volume distribution on harvester productivity. Analyses were based on data from 383 final fellings, with information on the mean productivity per stand and on volumes of all trees harvested per stand. Based on regression analysis, the mean productivity was found to be highly dependent on MTV ($p<0.001$, $R2=0.64$). When also adding the standard deviation (SD) of MTVs, as an indicator of volume distributions within stands, it also significantly ($p<0.001$) contributed to predict the productivity, and R2 increased to 0.70. At a given MTV, a small SD resulted in higher productivity than a large SD. Hence, tree-volume distributions should be considered to be included in future productivity models for harvesters, especially since such data starts to be readily available with current technological development.

Productivity models, regression, mean tree size

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2594 **Transport mechanism that can travel over Japanese forest lands**

SHIRAI, Y.* (1); ENDO, H. (1)

(1) Waseda, Faculty of Science and Engineering, Tokyo, Japan

Abstract: Japan's forestry operates in mountainous regions rather than hilly areas. And the logging road density is only 19.5 m/ha. However, it is not easy to develop new forestry roads and maintain them in Japan. Because Japan's forest lands are precipitous, soft terrain, wet and humid. Developing forestry roads sometimes cause mountain disasters in Japan. And the work of moving about and transporting heavy loads over irregular mountain forest terrain far from roads is still hard labor performed by humans. Then the authors have proposed and developed a machine that can travel and carry heavy loads in irregular mountain terrain that corresponds to the characteristics of mountain forests in Japan. This mobility runs through the mountain forests along after the humans. A demonstration model was built, experimented on, evaluated for its performance. So far the authors have developed mobility 1st and 2nd. This time reports mainly the 2nd one. By the way, the amount of a subsidy for Japanese forestry has considerably exceeded the lumber production. In 2013, the subsidies for afforestation and forestry roads amount to 290 billion yen. The author's technical developments aim to revitalize Japanese forestry.

Mobility Irregular terrain Mountain forest

Poster Exhibition Friday

209 - Safety and Health in Forestry

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2800 **The analysis of accident rate in Polish forestry: the influence of privatization on the status of accident rates**

Grzywinski, W.* (1); Skonieczna, J. (1); Jelonek, T. (1); Tomczak, A. (1); Burzynska-Jedrzejczak, G. (1); Naskrent, B. (1); Sawastian, K. (1)

(1) Poznan University of Life Sciences, Faculty of Forestry, Poznan, Poland

Abstract: Forestry is commonly considered a branch of economy with heavy work conditions and high risk of health and life in employees. At the beginning of the 90's of 20th century the privatization process in Polish forestry started. It affected the reduction of employment and emergence of private sector in forest services. Newly established sector took over almost all production works including timber harvesting and skidding, i.e. the operations responsible for the majority of accidents in forestry. This paper presents accident rates in Polish forestry in the years 1990-2014. The changes in accident rates in particular years during the privatization process of forestry works (public and private sectors) were analyzed. The structure of accidents (fatal, heavy, others), frequency rate, severity rate, their causes and results were also analyzed.

forestry, accident rates, privatization

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3193 **Forest operations and Habitats Directive: perspectives under the pressure of climate change**

Sitzia, T.* (1); Grigolato, S. (1); Campagnaro, T. (1); Cavalli, R. (1)

(1) Università degli Studi di Padova, Dept. TESAF, Legnaro, Italy

Abstract: In the last decades habitat conservation has assumed a key role in the management of forests, especially inside protected areas. In the European Union, the Habitats Directive (Council Directive 92/43/EEC) aims to preserve biodiversity favoring non-intensive interventions, which are usually based on historical references or on short-medium monitoring period over different forest management choices. However, climate change is expected to have significant impacts on forest ecosystems in the next decades as well as on forest management strategies. Therefore, it is crucial to understand if current limitations to forest operations aimed at reducing their impacts on habitats are still appropriate. In fact, it is well known that decisions made according to historical data without considering future trends are based on the assumption that the climate will remain relatively stable without taking into consideration the current climate change challenges. Moreover, climate changes have implications for forest operations themselves. For example, warmer winters reduce the opportunities for winter logging in areas where the frozen surfaces are essential for the bearing capacity of the soil and where snow pack is necessary to protect the soil and the related habitat during harvesting. Here we present some case studies of conservation measures that aim to mitigate the effect of forest harvesting operations in the Italian Eastern Alps, by considering the current trend in winter temperature increase and rainfall regime modification. The results of these case studies will be also discussed according to similar case studies identified by a review on the main scientific journal databases.

Natura 2000, management, harvesting, biodiversity

Poster Exhibition Friday

187 - Remote Sensing in Carbon Balance Evaluation and Monitoring

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1575 **Using time series satellite imagery to characterise disturbance in South East Australian forests**

Jones, S.* (1); Hislop, S. (1); Soto-Berelov, M. (1); Nguyen, T. (1); Haywood, A. (2)

(1) RMIT University, School of Science, Melbourne, Australia; (2) European Forestry Institute, c/o Embassy of Finland to Malaysia Wisma Chinese Chamber , Kuala Lumpur, Malaysia

Abstract: The sustainable management of forests is essential for a range of ecosystem services. Satellite earth observation is a powerful and cost effective means to monitor forest changes over large areas. The Landfor (Landsat for Forests) project uses 30 years of Landsat imagery to develop rich disturbance / recovery histories of the public forest estate in Victoria, Australia. Annualised composite images are stacked and analysed on a per pixel basis to assess forest changes over time. Results indicate that pixel-based time-series of Landsat data can successfully capture large area disturbances such as wildfire and logging, along with subsequent recovery and longer term trends like gradual forest decline. Smaller low intensity disturbances such as prescribed burns are harder to detect. The Landfor project has extended the capabilities of pixel-based time-series models by classifying disturbances by type (e.g. wildfire, fuel reduction burning, logging, disease, drought) by using a human interpreted reference dataset consisting of 10,000 points across the state, in conjunction with the Random Forests classifier. This approach serves as a tool that allows land managers to assess the impact of past management strategies on the condition of forests, and make more informed decisions going forward.

Time-series disturbance mapping satellite imagery

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3397 **On the potential to combine cross-border NFI data in remote sensing driven carbon stock assessment: Latvian and Lithuanian study**

Jonikavicius, D.* (1); Mozgeris, G. (1); Kulbokas, G. (1); Lukins, M. (2); Donis, J. (2); Zarins, J. (2); Lazdins, A. (2)

(1) Aleksandras Stulginskis university, Akademija, Kaunas region, Lithuania; (2) Latvian State Forest Research Institute "Silava", Salaspils, Latvia

Abstract: The nationally developed and used approaches for the assessment and monitoring of carbon budgets are quite frequently based on different approaches even for countries with similar forest conditions and forestry traditions. The presentation discusses the potential for combining National Forest Inventory (NFI) data crossing national borders to support remote sensing driven carbon stock assessment and mapping. The study elaborates on the outputs of case study done on Latvian-Lithuanian border area. We test the performance of information borrowing technique, expecting that field measurements in one area can also be used in neighboring areas. Medium resolution satellite images and non-parametric estimation are used to provide carbon estimates for smaller areas than it is possible with field data only. Latvian and Lithuanian NFI sample plot data is utilized as the input field information. Information, originating from mature forest stands inventory (a kind of systematic sampling based inventory following the NFI principles) in four Lithuanian State forest enterprises is used for the validation. The potential of mature forest inventory data to increase the field measurement sample is also investigated. Compatibility and usability of Latvian and Lithuanian NFI data for cross-boundary remote sensing driven applications is also discussed, including legal aspects for common data use.

satellite imagery, carbon budget, monitoring

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2278 **Large-scale mapping of forest standing volume with interferometric X-band SAR**

May, J.* (1); Solberg, S. (1)

(1) Norwegian Institute of Bioeconomy Research, Ås, Norway

Abstract: Tandem-X provids full coverage of InSAR data over Norway. This opens up for developing a wall-to-wall forest resource map over Norway. Earlier studies have demonstrated the strong and fairly stable relationship between the interferometric phase height above ground and standing volume. A number of issues has to be solved prior to this, including clarifying the effect of between-dataset variations in dielectric properties due to weather, what to do in areas without an accurate DTM and model selection.

The aim with this paper was to develop a method to map standing volume throughout Norway, based on detailed research in one selected county.

In 2015 Østfold, a Norwegian county was covered by 9 TanDEM X acquisitions. We processed the CoSSC data into a Digital Surface Model (DSM) with 10 m2 spatial resolution and mosaicked them into a seamless DSM. The entire county was covered by airborne laser scanning in 2015, and we obtained an accurate DTM with 10 m2 spatial resolution. We subtracted DTM from DSM and obtained InSAR height with full coverage, representing a canopy height model. 600 NFI plots provided the reference. All plots were circular (250 m2), and the field measurements included tree species, diameter at breast height (DBH), height on a number of trees and volume from Norwegian allometric models. For each field plot we selected one 10 m2 InSAR height- and coherence data set. Individual forest volume models were derived from the InSAR data using a linear regression. For InSAR height we used no-intercept analysis-of-covariance. This was done for different tree species, all acquisitions separately and -mosaicked.

Preliminary results showed a small difference between spruce and pine, however, not statistically different at the a=0.05 level. The analyses are currently in progress, and more results will be produced prior to the conference. We will compare simple linear models with biophysical models like Random Volume over ground (RVoG) and the two-level model (TLM).

InSAR, forest volume, volume modeling, TanDEM X

Poster Exhibition Friday

187 - Remote Sensing in Carbon Balance Evaluation and Monitoring

KG II - HS 2121 (Uni Freiburg)

IUFRO17-476 **Forest structure estimation using structure from motion approach with UAV in a managed coniferous forest**

Ota, T.* (1); Ogawa, M. (1); Mizoue, N. (1); Yoshida, S. (1)

(1) Kyushu university, Fukuoka, Japan

Abstract: Remote sensing plays an important role for forest monitoring. Recently, Unmanned Aerial Vehicle (UAV) has been increasingly used as the new platform for the aerial photography. Also, the development of the Structure from Motion (SfM) approach enables the production of 3D point cloud Semi-automatically. In this study, we investigated the utility of a canopy height model (CHM) derived from aerial photographs from Unmanned Aerial Vehicle (UAV) using the Structure from Motion (SfM) approach to estimate forest structure in managed coniferous forests, Japan. First we set up 20 rectangular sample plots within managed coniferous forests compose by Sugi (*cryptomeria japonica*) and Hinoki (*chamaecyparis obtusa*) and measured the diameter at breast height (DBH) and the height of trees. At the same time, aerial photographs were acquired over the plots using UAV. A 3D point cloud was generated from aerial photographs using the SfM approach and converted to a digital surface model (DSM). From the DSM and the digital terrain model constructed from airborne LIDAR, we created CHM. Then, we estimated stand volume and mean tree height using the metrics derived from CHMs. In conclusion, forest structures can be estimated from CHM derived from aerial photographs acquired from UAV using the SfM approach.

UAV; SfM;Stand volume; Mean height

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3779 **China typical forest aboveground carbon estimation by fusion of multi-platform data**

Pang, Y.* (1)

(1) Institute of Forest Resource Information Techniques, Chinese Academy of Forestry, Beijing , China

Abstract: China has a wide variety of forest types. It is challenging to make a reliable estimation of these forest biomass using geo-spatial technologies. We developed a Field-Airborne-Spaceborne (FAS) observation method for forest biomass estimation. According to forest ecological zones of China, we carried out three FAS campaigns in the Northeast, central, and Southwest China. Airborne lidar and hyperspectral data were collected along National Forest Inventory (NFI) plots. Then the airborne lidar data were used to estimate carbon after been trained by NFI plots. The stratification of forest types improved the Lidar estimation capability of 5 - 13%. This Lidar estimated carbon was used to training satellite data for large area carbon mapping. The stratified regression tree modeling method implemented in CUBIST software package was used. The stratified regression tree modeling method was used. The overall estimation correlation coefficient are better than 0.8.

forest, Field-Airborne-Spaceborne observation

Poster Exhibition Friday

69 - Urban forestry for quality of life - the impacts of research on everyday practices

KG II - HS 2121 (Uni Freiburg)

IUFRO17-41 **Urban forest as sanctuary for a threatened indigenous tree species in Southwest Nigeria**

Babalola, F.* (1); Borokini, I. (2); Onefeli, A. (3)

(1) Department of Forest Resources Management, Faculty of Agriculture, Ilorin, Nigeria; (2) University of Nevada, Reno, United States; (3) University of Ibadan, Department of Forest Resources Management, Ibadan, Nigeria

Abstract: Indigenous trees have been disappearing at alarming rates. Milicia excelsa (popularly known as Iroko) is an indigenous trees species in tropical Africa. The tree species is classified as threatened and fast disappearing due to its extensive exploitation for timber. However, remnants of the trees could still be found in some strategic locations in urban areas. A survey of the trees was carried out in Ibadan to determine the distribution while semi-structured questionnaire was administered to the people living close to the trees to determine the socio-economic benefits. A total of 78 trees were enumerated, out of which majority (59.5%) were sampled in University of Ibadan, and the remaining in the city metropolis. The tree provides ecosystem services ranging from environmental to medicinal, economic, spiritual and ecological. There is a need for an appropriate policy that protects indiscriminate felling of trees in the city and appropriate management strategy for indigenous tree species.

Milicia excelsa, Ibadan, Indigenous tree

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3847 **ArboCityNet - A cross-sectoral and transdisciplinary Swiss Urban Forestry Network**

Baerlocher, B.* (1); Wilkes-Allemann, J. (2); Lieberherr, E. (2); Hegetschweiler, T. (3); Dirac, C. (4)

(1) HAFL, Zollikofen, Switzerland; (2) ETHZ, Zürich, Switzerland; (3) Eidgenössische Forschungsanstalt WSL, Birmensdorf, Switzerland; (4) Bundesamt für Umwelt, Ittigen, Switzerland

Abstract: Urban forestry is confronted with many social and ecological interactions in and around cities. Thus, overcoming typical disciplinary and sectoral thinking may help to meet these challenges and promote transdisciplinary and inter-sectoral decision-making concerning green urban infrastructure.
Subsequently and in accordance with the EFUF, a group of Swiss research institutes and associations (HAFL, ETHZ, WSL, ZHAW, HSR, hepia, Plante & Cité Suisse) with the support of the Swiss Federal Office for the Environment founded ArboCityNet in Berne in 2016.
The aim of the network is to bridge a) different research fields such as landscape architecture, arborists, forest engineers and social scientists, and b) research fields with expertise in cities, including political decision-makers and public servants. The founders and members of ArboCityNet come from different sectors and from different regions in Switzerland. The Network therefore helps to overcome typical language boundaries in the country and different constituent-state practices. On-going knowledge exchange is maintained via annual conferences and events.

We think that presenting ArboCityNet in a poster presentation at IUFRO will enable an exchange with experts working in the same domain. Moreover, we could contribute by serving an example of how such inter-sectoral cooperation can help to shape and inspire the green urban infrastructure in cities.

partnership, research and practise exchange

KG II - HS 2121 (Uni Freiburg)

IUFRO17-496 **Valuation of Royal Tombs of Joseon Dynasty as Urban Forest**

Lee, P.* (1); Chung, D. J. (2)

(1) Hanyang University, Graduate School of Urban Studies, Seoul, Korea, Republic of (South Korea); (2) National Forestry Cooperative Federation , Seoul, Korea, Republic of (South Korea)

Abstract: Royal tombs in Joseon Dynasty had been built in and around Seoul, the capital of Korea. They treasure historical and cultural values to Koreans. The conditions of the royal tombs have been maintained conservatively, and they were designated as World Cultural Heritage in 2009. Whereas royal tomb spaces are ceremoniously covered with selected species such as Pinus densiflora and Abies holophylla, their surrounding forests were filled with diverse native species. As the forests have not been seriously treated compared to the royal tomb spaces, we expected to find ecological values of them. This study was aimed at identifying current conditions of royal tomb forests. We selected five royal tombs of Joseon Dynasty within and around Seoul, collected ecological information from the selected royal tombs' surrounding forests, and identified the differences among them. We measured i) number of trees, tree height, DBH and big trees for forest analysis, ii) number of species, endangered and rare species for flora and fauna analyses, iii) physical and chemical features of soil, and iv) presence of disturbances within the forested areas. All forests showed the red pine-centric composition in common, but growth pattern and species composition and diversity varied among the forests. There were only natural disturbances found, and the disturbances caused minor damages to the forests. Overall, the pine populations for all sites showed the trend of the decrease in the growth rate. For present species, while Heonneung showed a large number plant and insect species, a small number of insect species was observed in Saneung despite a relatively large number of plant species. Each royal tomb indicated various ecological characteristics. Consequently, these forests showed the implication that they have been going through a healthy ecological process. This result will be the base of follow-up research to develop a scientific analysis-based sustainable management for the royal tomb forest.

Urban forest, ecological value, sustainability

Poster Exhibition Friday

69 - Urban forestry for quality of life - the impacts of research on everyday practices

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1447 **The relation between citizen's wellness and their attendance in urban forests, Lithuania**

Bernat, A. (1); Marozas, V.* (1); Zalkauskas, R. (1)

(1) Aleksandras Stulginskis University, Kaunas r., Lithuania

Abstract: Frequently urban territories are expanded by reducing the surrounding green spaces. Over the past decade, the increase in urban areas has led to an obvious lack of well-ordered greenery, especially in new residential areas. Urban forms a healthy and aesthetic environment, improves the composition of air, reduces air pollution and noise, increases air humidity, prevents dust from flying in the air and affects the urban climate. A number of studies have shown that the natural environment has a positive impact on people's health, well-being and physical activity and creates favourable conditions for the population. The aim of the study was to determine relation between urban forests and human health. The questionnaire was distributed to the cities dwellers. More than 500 respondents filled the questionnaire. Chi-square test was used to determine differences in distributions between the groups of respondents. Multivariate analysis methods were applied to identify relations between urban forest attendance and dwellers well-being. The results showed during the summer, about 25 percent of the respondents visited urban forests 4 times a week and more often; in winter time - only one time a month. During the visit dwellers spent 1-3 hours in the forest. 16 percent of respondents felt the stress, fatigue or was in a bad mood or felt distracted at least once a week. It was found relation between resident's well-being and attendance in urban forests.

human health, questionnaire, urban forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2413 **Spatial-temporal changes of urban forest landscape patterns, woody plants and bird species, and biomass and soil carbon functions in Harbin City, Northeastern China**

wang, W.* (1); he, X. (1); lv, H. (1); xiao, L. (1)

(1) Chinese Academy of Sciences, Changchun, China

Abstract: In China, rapid urbanization has profoundly changed the spatial pattern of urban land use, including urban forests, and impact species diversity and carbon sinks function. Taking Harbin City as an example, we quantified urban forests landscape patterns, tree-shrub and bird species, biomass and soil carbon storage along urban-rural gradients and history of urban settlements based on remote sensing images and field study. Conclusions are as follows.
Landscape of urban forests in Harbin was highly fragmented, and the fragmentation of landscape was interacted with carbon storage functions in trees and soils. LSI increased along with urban-rural gradients (r2 ranges 0.72 to 0.93, $p < 0.05$), and its positive relations with SOC indicates LSI possible contributing to underlying mechanism of urbanization-induced carbon accumulation in high urbanized regions.
Urbanization caused a dramatic shift in the diversity of wood plant species and the composition of woody plants and birds. The richness of woody plant families and species increased signiﬁcantly due to urbanization, especially that of alien species and tropical types. Transition areas (moderate disturbance region) usually had much higher richness and diversity of alien species. The bird changes may be coincided with the tree species increases.
During 30 years expansion, urban lands increased 0.68 km2 yr-1 from 1985 to 2001, and 9.46 km2 yr-1 from 2001 to 2014. The percent of forestlands landscape linearly increased in the initial state of urban sprawl from 1985 to 2001 and decreased less in the fast urbanization state from 2007 to 2014. Carbon stocks in forest land increased greatly from 0.61 Tg C in 1985 to 1.41 Tg C in 2007, then slightly decreased to 1.14 Tg C in 2014
Our findings highlighted that urbanization effects should be incorporat into evaluation of biodiversity and biomass and soil C budgets in regions subject to rapid urban sprawl, and this is also useful for ecological re-construction of local cities.

landscape metrics; carbon stock; biodiversity

Poster Exhibition Friday

161 - Combined and interactive effects of multiple stressors on forest health

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2174 **Antioxidant capacity in poplar exposed to ozone and/or drought**

Dusart, N.* (1); Vaultier, M.-N. (1); Gerard, J. (1); Le Thiec, D. (2); Jolivet, Y. (1)

(1) Université de Lorraine, Faculté des sciences et technologies, Vandoeuvre-lès-nancy, France; (2) INRA, UMR 1137 Ecologie et Ecophysiologie Forestières, Champenoux, France

Abstract: Nowadays, plants are facing stronger environmental stresses due to anthropogenic atmospheric pollution. That leads to an increase of oxidative stress for trees. To protect forest health, we need to improve risk assessment, taking into account detoxification mechanisms and interacting stresses. For example, the impact of drought events on the effect of ozone (O3) pollution needs a special attention. Indeed, drought may alleviate the O3 entrance in the leaf by reducing the stomatal aperture; however, drought also induces changes in cell redox homeostasis. Also, the behaviour of the cell antioxidative charge in case of stress combination (drought and O3) is still little investigated. We intend to decipher the response of detoxification mechanisms relative to Halliwell-Asada-Foyer cycle (HAF) in condition of combined stresses (drought and O3). Genotypes of Populus nigra x deltoides were exposed to various treatments during 17 days: i) a mild drought, ii) an exposure to 120 ppb O3 and iii) a combination of both treatments. Ascorbate and glutathione pools (reduced and oxidized), enzyme activity and expression of the different gene isoforms coding for HAF proteins were studied. Depending the isoforms, and probably linked with the putative localization of ROS production in response to drought and ozone, respectively, different expression profiles were observed. The activity of associated enzymes was modified with an intermediate level for combined treatment compared to drought and ozone separately.

Poplar, Ozone, Drought, Ascorbate, Glutathione

KG II - HS 2121 (Uni Freiburg)

IUFRO17-374 **The Effect of Soil Moisture Potential on the Pathogenicity of Leptographium terebrantis and Grosmannia huntii on Pinus taeda L.**

Devkota, P. (1); Eckhardt, L.* (1); Enebak, S. (1)

(1) Auburn University, Auburn, United States

Abstract: The interactions of biotic and abiotic factors on the health of Pinus spp. can be complex.The aim of this study was to determine the combined effect of soil moisture and pathogenic stress on the growth and survival of Pinus taeda L. We studied two P. taeda families (one susceptible and another tolerant to Leptographium terebrantis and Grosmannia huntii). Three watering treatments; a) normal moisture b) medium moisture stress and c) low moisture. One month following the establishment of the watering treatments, fungi; L. terebrantis and G. huntii, and controls; wound, wound + media, and no wound were applied. Predawn water potential, stomatal conductance, number of bud development were measured at the end of the experiment. Plant-biomass, lesion, and occlusion (blocked vascular tissue) are being measured. Results to date show that the needle water potential decreases in seedlings from the susceptible family under low moisture conditions compared to seedlings in the tolerant family. Grosmannia huntii resulted in greater reductions in water potential in the susceptible family under low soil moisture conditions. These findings indicate that there is an interaction between soil moisture and the pathogenicity of ophiostomatoid fungi on P. taeda.

Leptographium terebrantis, Grosmannia huntii

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1305 **Environmental maternal effects on the phenotype and interactions of Eucalyptus seedlings**

Vivas, M.* (1); Kemler, M. (1); Wingfield, M. J. (1); Slippers, B. (1)

(1) Forestry and Agricultural Biotechnology Institute (FABI), Pretoria, South Africa

Abstract: The environmental "experience" of plants can influence their offspring and thus their biotic interactions, without modifications to their DNA sequence. In this study, we consider the influence of different maternal environments on the phenotype, physiology and resistance of Eucalyptus grandis seedlings and their potential impact on the foliar fungal communities of the seedlings. Seeds were collected from replicates of the same clones from two E. grandis clonal seed orchards subjected to different abiotic and biotic conditions. Seed and seedling development, seedling photosynthesis and seedling response to a pest and a pathogen were measured. Finally, foliar fungal communities of the seedlings, which were grown in a common garden, were assessed using a metabarcoding approach. Height and water use efficiency were different in seedlings grown from the contrasting maternal environments ($P<0.05$ and $P<0.001$). Seedlings from one of the maternal environments were more resistant to the pathogen than seedlings from the other ($P<0.05$). Although not significant, the same seedling response against pest infestation was found ($P=0.453$). Fungal communities also differed between the offspring from the two maternal environments ($P<0.05$). The results demonstrate that differences in the environment in which Eucalyptus trees grow can affect the phenotype, physiology, and resistance of their progeny. Additionally, we suggest that the maternal environment can define the structure of fungal communities in the subsequent generation.

phenotype, epigenetic, physiology, microbiome

Poster Exhibition Friday

71 - Early detection and monitoring of invasive forest pests and pathogens with citizen science

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4121 **Citizen Science helps to combat invasive Phytophthora diseases in southern Sweden**

Cleary, M.* (1); Witzell, J. (1)

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Abstract: In southern Sweden, invasive Phytophthora species are impacting important noble broadleaved trees species including European beech (Fagus sylvatica) and pedunculate oak (Quercus robur), both in forested and urban landscape settings. During recent years, there has been a dramatic surge in the number of inquiries from forest managers and other stakeholder representatives, as well as concerned citizens, requesting advice on invasive Phytophthora pathogens and how to manage Phytophthora-damages in amenity trees and forests. Citizen Science holds huge potential for advancing spatial prediction of biological invasions by providing inexpensive location-based, time series data of unprecedented quantity and distribution. In a new project that employs a 'genes-to-landscape' approach to reveal the patterns of species distribution and genetic diversity of invasive Phytophthora species populations, we harness the interest of these stakeholders and citizens by involving them into the science. Voluntary partnerships have been established that aim at systematic collection of samples and interactive dissemination of results. This Citizen Science platform has now facilitated a database for disease distribution in Sweden, targeting under-sampled habitat within urban areas and along the forest-urban interface at a much greater pace and over larger geographic areas, and aided in the reciprocal flow of information between researchers and stakeholder groups.

Citizen Science, Phytophthora spp. distribution

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IUFRO17-3746 **Cape Citizen Science: public engagement to detect and discover Phytophthora species in South Africa.**

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Abstract: Cape Citizen Science (http://citsci.co.za/) is a project designed to involve the public in a Phytophthora species survey of the Cape Floristic Region of South Africa. The survey is important because Phytophthora species cause forest epidemics in many parts of the world and little is known about the identity and distribution of these organisms in South Africa. Cape Citizen Science uses a contributory model where citizens can share observations or submit samples for diagnosis. Preliminary results indicate that non-scientists provide a valuable source of support to record disease incidence and to submit Phytophthora samples for hypothesis driven research. This project increasingly demonstrates that citizen science is an important tool to increase monitoring capacity and to promote the early detection of invasive plant pathogens. This approach can be used in emerging and developing economies and similar projects could facilitate research about this important group of plant pathogens around the world.

citizen science, public engagement, Phytophthora

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IUFRO17-3149 **VigiCasta: a citizen science project dedicated to chestnut ink disease.**

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Abstract: Chestnut ink disease which is spreading in northern France and in Europe, is a root disease caused by Phytophthora cinnamomi and P. cambivora . Is the increase of chestnut ink disease reports due to climatic change, sylvicultural practices or involvement of other Phytophthora species? In order to answer these questions and to recommend chestnut owners how to manage infected chestnut sites, forest pathologists need to know the distribution of chestnut tree Phytophthora spp. However, symptoms of ink disease are not always easy to diagnose and it is difficult to disentangle the different risk factors. Thus, the first step is to localize chestnut ink disease symptoms and the second to perform laboratories analyses.
For this goal, INRA has developed a citizen science program called VigiCasta, based on two nomad applications making possible participatory science actions:
- Di@gnoplant, a tool for diagnosis in plant and forest health
- the AGIIR application (Alert & Manage Invasive Insects and / or Pests) which allows to study on a large scale the distribution of several major emerging pests
These applications, which can be downloaded on smartphones, allow citizens to recognize chestnut ink disease symptoms, signal their presence and sample plant material for analyses.

Phytophthora; monitoring; detection; diagnostic

Poster Exhibition Friday

71 - Early detection and monitoring of invasive forest pests and pathogens with citizen science

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IUFRO17-795 **P-FOR INIA: a new app for the forestry sector in Uruguay**

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Abstract: Early detection of forest pests and diseases is crucial to develop management strategies aimed at mitigating its impact on commercial plantations. We developed the pest and disease recognition smartphone app P-FOR INIA, targeting foresters, students and general public. It consists of three modules: a library, a symptom key, and a query module. In the library module, users can access different factsheets with information about the most important forest pests and diseases of eucalypts and pines in Uruguay. The symptom key module provides an interactive key users can rely on to identify forest health problems through a set of guided questions. In the query module, users can take pictures and post a query about the problem they are looking at. A group of forest health experts is responsible for the answer. This tool allows incidental data collection on distribution and seasonality of key forest pests and diseases, and it also improves communication between foresters and tree health experts regarding forest health topics. New modules such as pest and disease alerts, new pest and disease reports, and national monitoring and surveillance data management could be incorporated in the future.

forest health, smartphone application, Uruguay

Poster Exhibition Friday

192 - Global decline of Fraxinus species caused by invasive pests and pathogens

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1805 **Natural infection of Fraxinus angustifolia by Hymenoscyphus fraxineus in Slovakia**

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Abstract: The fungus Hymenoscyphus fraxineus is responsible for dieback of common ash (Fraxinus excelsior) and in some parts of Europe also of narrow-leaved ash (F. angustifolia). The first symptoms of ash dieback have been recorded on F. excelsior in Slovakia since 2004. This study reports about the first natural occurrence of H. fraxineus on F. angustifolia in Slovakia. The field investigation was carried out in 2014. The segments of diseased shoots and last year's petioles were collected in clonal seed orchard situated in southwest part of the country. The fungus was isolated from infected host tissue and identified using molecular techniques (DNA extraction from pure cultures and apothecia, conventional PCR).

isolation, apothecia, DNA extraction, ash dieback

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3135 **Assessing the potential invasiveness of Hymenoscyphus fraxineus in the Mediterranean mountains**

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Abstract: *Hymenoscyphus fraxineus* is an aggressive ascomycete that in just a few years invaded large parts of Central and Northern Europe causing dieback in *Fraxinus excelsior* and *F. angustifolia*. The fungus, present in the Alps for some time, was recently discovered in a small area of the Northern Apennines, which is the southernmost disease focus to date. The pathogen's potential to adapt to the local environment, spread and become established in the Mediterranean mountains is unknown. Tests were carried out to characterize both ecologically and genetically the population found in the Italian Apennines. In vitro growth tests were performed to understand the population's reaction to the relatively high summer temperatures that might limit fungal growth or survival in the Mediterranean mountains. In vitro growth tests on leaf enriched media were performed to understand how leaf age influences mycelial growth, and to provide circumstantial evidence about the relation between host leaf phenology and fungal infection, which might undergo major changes with climate either impairing or improving disease development. Finally vegetative compatibility between local and non-local isolates of the fungus was assessed as to obtain a measure of the population's genetic variability. A number of isolates had optimum growth temperature higher that 20 °C, the most common value also in populations from Central Europe. All isolates resumed growth with no apparent damage after thermal stress at 28 °C for 6 weeks. A great genetic variability was found in the population that, together with the tolerance to relatively high temperature, may increase the population's potential to survive and adapt to the Mediterranean environment. The competence of host leaves to support fungal growth was maximum in late spring but declined during summer. On synchronization between optimal sporulation pressure and leaf receptivity in this climate will depend the capacity of the pathogen to become invasive in the area.

Italian Appennines,growht tests,population studies

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1987 **Hymenoscyphus fraxineus at eastern border of its secondary range in Europe**

Zviagintsev, V. (1); Seraya, L. (2); Panteleev, S. (3); Yaruk, A. (1); Baranchikov, Y.* (4)

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Abstract: In spite of quick distribution of ash dieback disease in Europe, till recently only limited information on invasive micopathogen Hymenoscyphus fraxineus Baral et al. has been available for the eastern part of natural range of European ash Fraxinus excelsior L. In 2014-2016, we covered about 14 000 km exploring most eastern corner of F. excelsior range in European Russia. The infected samples were collected in 162 plots situated in forest belts along highways, in cities and sometimes in natural forest stands of 23 administrative regions of Russia. Samples were taken from F. excelsior, as well as from F. pennsylvanica Marshall, F. americana L. and F. ornus L. which were present in the plots. Genetic analysis proved existence of H. fraxineus in 86% of the samples. We found no vivid regularities in distribution of fungus activity from Poland and Byelorussia across the region to the river of Volga. The mature trees of F.excelsior were the most resistant to the disease comparing to other ash species. Young trees and sprouts were infested more intensively. Their chronic injury took place at least during last 7-8 years.
Different hypothesis on the time of H. fraxineus invasion and its distribution in European Russia will be discussed. The work was supported by the Russian Foundation for Fundamental Research (grant 17-04-01486).

Hymenoscyphus fraxineus, distribution, W. Russia

Poster Exhibition Friday

192 - Global decline of Fraxinus species caused by invasive pests and pathogens

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2190 **Hymenoscyphus fraxineus shows population density dependent growth rate**

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(1) Norwegian Institute of Bioeconomy Research, Ås, Norway

Abstract: The invasive, pathogenic *Hymenoscyphus fraxineus* has recently spread across Europe resulting in a serious dieback in ash trees. One of the causes for the successful invasiveness seems to be its capability of rapid increase in population size, while another appears to be its outcompeting of the indigenous and harmless saprophyte *Hymenoscyphus albidus*. Because these two closely related species, similar in morphology and ecological preferences, but very different in pathogenicity, inhabit the same ecological niche, co-monitoring of their population dynamics can increase our understanding about mechanistic interactions that facilitate the invasion success of *H. fraxineus*.
To examine the build-up rate of the pathogen population size and to map the temporal dynamics between the two species, we sampled airborne spores by using a Burkard 7-day volumetric sampler during six growing seasons, from 2011-2016 in an ash forest at the west coast of Norway with a disease history dating back to 2010. Spores of *H. fraxineus* and *H. albidus* were quantified by species-specific real-time qPCR assays. In 2011 the level of *H. fraxineus* spores was low and comparable to those of *H. albidus*, and the two species still co-existed in the stand. Between 2011 and 2013 *H. fraxineus* showed relatively linear increase in spore amount, while *H. albidus* showed concomitant decline. After 2013 spores of *H. albidus* were no longer detected whereas *H. fraxineus* showed an exponential increase in the period 2013-2015. The linear-to-exponential sequence in the growth rate of *H. fraxineus* population suggests that the increment in population size depends on the level of infection pressure. The disappearance of *H. albidus* relates to its low initial population size and to the exclusive competition by *H. fraxineus* as the two species compete for the same sporulation niche. The influence of weather conditions and environmental carrying capacity on population dynamics of *H. fraxineus* and *H. albidus* are discussed.

Ash dieback, Burkard sampler, spore sampling, qPCR

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IUFRO17-2171 **First experiences in breeding for resistance against ash dieback in southern Germany**

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Abstract: The invasive ash dieback pathogen *Hymenoscyphus fraxineus* is responsible for massive decline of ash (*Fraxinus excelsior*) populations throughout Europe. In southern Germany, forestry aims to preserve and promote individuals with high levels of partial genetic resistance to allow the transmission of the resistance to future ash generations by natural regeneration. Resistance breeding in clonal seed orchards may be an effective possibility to support and accelerate this process of adaption. The Bavarian Office for Forest Seeding and Planting and the Forest Research Institute Baden-Württemberg cooperate in assessing the potential for resistance breeding by using several research approaches.
Putative resistant plus-trees were selected and propagated in 2012 by grafting. Two years later, the resulting 36 clones were planted in two different sites with natural infection pressure. Subsequent yearly monitoring of the health status revealed fast infection of the clones. Only few clones still indicate high levels of resistance and may be suitable for further propagation.
Seeds from 30 putative resistant ash trees were collected and sown in 2013. More than 1900 of the resulting seedlings were planted in two sites in winter 2015/2016. An assessment of the health status in summer 2016 revealed first infections of the seedlings. Data collections will be repeated yearly in future.
In Baden-Württemberg, the health status of ash trees in certified seed stands is foreseen to be monitored over several years. In Bavaria, observations will be performed in stands where monitoring of ash dieback has started in 2009. The gained data will allow assessing the potential for conservation of resistant genotypes by either promotion of natural regeneration in these stands or producing grafts and planting them in seed orchards.
This presentation will outline first experiences in plus-tree selection and propagation and foreseen future activities in resistance breeding in southern Germany.

Ash dieback, Fraxinus excelsior, resistance

Poster Exhibition Friday

192 - Global decline of Fraxinus species caused by invasive pests and pathogens

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3058 **The double invasion of Far Eastern consumers of ash in the collection of Fraxinus species in the Main Botanical Garden of the Russian Academy of Sciences (Moscow)**

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(1) All-Russian Research Institute of Phytopathology, Bol'shiye Vyazemy, Russian Federation; (2) Main Botanical Garden RAS, Moscow, Russian Federation; (3) Belarusian State Technological University, Minsk, Belarus; (4) Sukachev Institute of Forest SB RAS, Krasnoyarsk, Russian Federation

Abstract: 24 taxons of the genus Fraxinus L. are growing in collection of the Main Botanical Garden of the Russian Academy of Sciences (Moscow). This collection was at the epicenter of a double invasion of Far Eastern consumers of ash: Agrilus planipennis Fairmaire (Coleoptera, Buprestidae) or EAB and pathogenic fungus Hymenoscyphus fraxineus (T. Kowalski) Baral, Queloz, Hosoya or AD and was almost fully destroyed. The method of dendrochronological cross dating established that the dieback of ash trees with EAB took place from the beginning of the 90s of the last century and continued until 2014. The collection lost 51,3% (173 pcs.) of trees. The following taxons were damaged: F. americana L., F. americana var. iodocarpa Fern., F. angustifolia Vahl., F. excelsior L., F. excelsior "Aurea" (Pers.) Schelle, F. excelsior "Diversifolia" Lingelsh., F. lanceolata Borckh., F. nigra Marsh., F. ornus L., F. oxycarpa Willd., F. pennsylvanica Marsh., F. rotundifolia Mill. On the weakened trees of F. americana var. joglandifolia (Lam.) D.J. Browne and F. mandshurica Rupr. single damages of EAB were found.
EAB did not damage: F. biltmoteana Beadle., F. bungeana DC., F. chinensis Roxb. (=F. rhynchophylla Hance), F. excelsior "Argenteo-variegata", F. excelsior "Nana", F. latifolia Benth.(=F. oregona Nutt.), F. quadranqulata Michx., F. profunda (Bush) Bush (=F. tomentosa Michx. L.), F. sogdiana Bge., F. velutina var. glabra Rehd. The dieback of trees was stopped after felling of dead trees in the winter 2014-2015. It coincided with the disappearance of EAB in Moscow and the Moscow region. But symptoms of another invaider: pathogen AD were found on the young shoots in the collection. Genetic analysis proved existence of H. fraxineus among the following species: F. excelsior, F. ornus, F. mandshurica. Pathogen discovered in trace amounts on the F. chinensis (= F. rhynchophylla).
The work was supported by the Russian Foundation for Fundamental Research (grant 17-04-01486).

Agrilus planipennis, Hymenoscyphus fraxineus

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IUFRO17-1718 **Progression of ash dieback in Norway related to tree age, disease history and regional aspects**

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Abstract: Ash dieback, caused by the invasive ascomycete Hymenoscyphus fraxineus, has spread throughout Europe since the early 1990s, threatening European ash at a continental scale. Little is known about the development of the disease in individual forest trees and in different age classes. In this study we monitored ash dieback on trees of three different diameter classes in five permanent plots in ash stands in south-eastern Norway from 2009 to 2016, and from 2012 to 2016 in three plots in western Norway with a shorter disease history. Our results showed that more than 80 % of the youngest and more than 40 % of the intermediate future crop trees in the plots in south-eastern Norway were dead by 2016, while the disease development in large, dominant trees was slower. Although less damage has been observed in the plots in western Norway, the trend for the juvenile trees is the same as in south-eastern Norway with rapidly increasing damage and mortality. Most dead trees in south-eastern Norway were found at sites with high soil moisture and showed symptoms of Armillaria root-rot. Infected trees are weakened by the disease and appear to be more susceptible to other, secondary pathogens, especially under unfavourable site conditions.

Ash dieback, annual & regional disease development

Poster Exhibition Friday

170 - Understanding viruses in trees - promoting healthy plants in forest and urban open space

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IUFRO17-791 **Detection of Elm mottle virus (EMoV) and a putative novel Carlavirus in the genus Ulmus in northern Germany**

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Abstract: Leaves of elm trees showing virus-like symptoms such as mottling, chlorotic ringspots, line pattern, necrosis and mosaic were collected in the northeastern part of Germany and were analyzed by molecular methods. Some of the elm trees were infected by *Elm mottle virus* (EMoV). This virus is an ssRNA(+) virus with isometric particles belonging to the genus *Ilarvirus* which is known to affect different elm species. EMoV detection was based on PCR primers derived from the RNA1 or RNA2 as well as specific primers targeting the RNA3, which codes for the movement protein and the viral coat protein. Furthermore, in symptomatic European White elm (*Ulmus laevis* L.) filamentous viral particles have been observed, which lead to the assumption of an infection with an additional virus. Next generation sequencing data of total RNA from a diseased elm tree identified contigs exhibiting highest identities to plant viruses of the family *Betaflexiviridae*. Together with observed particle morphology this led to the assumption that the elm tree was infected by a putative novel *Carlavirus*. To investigate whether this virus could be associated with the symptoms found in elms, specific primers detection of this putative *Carlavirus* were designed. Symptomatic and asymptomatic trees were tested by RT-PCR. Results are presented and evaluated dealing with the occurrence of EMoV and the putative novel *Carlavirus* in elm trees and their association with observed virus-suspected symptoms.

RT-PCR, European White elm, filamentous particles

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1785 **A novel putative Badnavirus associated with the 'birch leaf-roll disease' in Europe**

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Abstract: A virus-associated birch epidemic constitutes a serious current problem for the birch forests and urban stands health throughout Europe. The disease was first recognised as a phytopathological problem in Finland and was described as 'birch leaf-roll disease' in 2006. Diseased trees exhibit foliar disorders including vein banding, leaf roll, chlorosis with subsequent necrosis gradually leading trees to decline. Transmission by grafting from symptomatic *Betula pubescens* donor trees from Rovaniemi, Finland, to non-symptomatic *B. pubescens* seedlings was successful and the grafted seedlings developed symptoms similar to those of donor trees. NGS data obtained by RNA-Seq analysis using leaf tissues from the grafted seedlings as well as from the original donor trees showed that the grafted *B. pubescens* seedlings were predominantly infected by a novel putative *Badnavirus* genus member. Badnaviruses are double-stranded DNA pararetroviruses and one of the eight genera of the family *Caulimoviridae*. They have bacilliform particles and replicate through an RNA intermediate, like retroviruses. The new virome data offer new interpretations regarding the cause of the 'birch leaf-roll disease', including the possible involvement of either the new Badnavirus or a complex of viruses. The novel Badnavirus is suggested to play a principal role in the disease development, as different lines of evidence suggest its episomal, infectious activity.

badnavirus, birch leaf-roll disease, NGS

KG II - HS 2121 (Uni Freiburg)

IUFRO17-546 **A novel virus is associated with the ringspot disease in Common oak (Quercus robur)**

von Bargen, S.* (1); Rehanek, M. (1); Mühlbach, H.-P. (2); Rumbou, A. (1); Candresse, T. (3); Kube, M. (4); Bandte, M. (1); Büttner, C. (1)

(1) Humboldt-Universität zu Berlin, Division Phytomedicine, Berlin, Germany; (2) University of Hamburg, Biocenter Klein Flottbek, Hamburg, Germany; (3) INRA, Univ Bordeaux, Villenave d'Ornon, France; (4) Thünen Institute, Institute of Forest Genetics, Waldsieversdorf, Germany

Abstract: A novel putative *Emaravirus* was identified by high-throughput sequencing in a sample obtained from diseased Common oak (*Quercus robur* L.) from a seed production stand in Fellinghausen, Germany. Like other Emaraviruses it is composed of four monocistronic genome segments. Each of this core of genome segments encode a single open reading frame in negative orientation; RNA1 consists the replicase, RNA2 a glycoprotein precursor, RNA3 the viral nucleocapsid protein, and RNA4 the putative movement protein of approx. 42 kDa. Some members of the genus contain up to four additional genomic RNAs encoding additional proteins of unknown function. The affected oak tree expressed chlorotic ringspots and mottling of leaves since several years. The association of the discovered novel Emaravirus with observed symptoms was studied by RT-PCRs targeting the viral RNA1, RNA3 and RNA4, respectively. Leaves from oak trees were sampled from sites in different European countries including a seed collection stand and park, road side or forest trees. Virus detection was closely correlated with Commons oak exhibiting characteristic chlorotic ringspot symptoms while it was neither detectable in leaf material collected from trees without virus-like symptoms nor other Quercus spp. showing regular chlorotic patterns or partial chloroses of leaves. Results further confirmed that the virus also affects the *Q. robur* cv. "Fastigiata Koster" (Cypress oak) which is a very popular decorative ornamental tree due to its upright branches leading to the columnar shape of the canopy.

Emaravirus, RT-PCR, chlorotic ringspots

Poster Exhibition Friday

27 - Community forestry/ Co-management as a possible solution for forest governance and livelihood

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2522 **Linking Devolved Tenure Systems and Forest Management Outcomes: Progress and Challenge**

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Abstract: Forest tenure devolution has attracted broad attention for addressing such issues as reducing deforestation and forest degradation, promoting forest restoration and management, and improving ecosystem functionality. How these issues are addressed will in turn influence climate change mitigation, community livelihoods, and sustainable development. While progress has been made in empirically linking devolved tenure systems with forest management outcomes, significant knowledge gaps remain. This presentation will first identify the research achievements and the knowledge gaps. It will then deliberate how to overcome the challenges and thus facilitate more effective tenure devolution and governance reform. It is found that a majority of the studies have examined forest cover and its change in relation to tenure and governance reform; growing stock, density, and removal are rarely considered, let alone diversity and integrity. Few have been able to combine the most robust methods from both the ecological and social sciences into a coherent research plan. Also, additional governance and capacity constraints must be addressed to result in improved management outcomes. Future work will be strengthened by supporting more rigorous studies that draw on the project design of impact evaluation, build datasets with broader coverage and better quality, and elucidate the complex relationships across scales.

Tenure devolution, management outcome, governance

Poster Exhibition Friday

203 - Forests for sustainable development: shifting discourses and approaches

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1173 **A Conceptual Banking Model for Forest Biodiversity Productization in North Europe**

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Abstract: Bio-economy builds on sustainable utilization of renewable materials, such as wood. However, it also covers ecosystem services. The drivers of bio-economy include climate change, as well as the increasing basic needs of the growing human population, such as food, housing, water and energy. The increasing demand for renewable materials and food underline the need for even more intensive management of forests for supply of wood. Howeve, this creates a potential challence for sustainability. Thus bioeconomy also calls for innovative new approaches in policies regarding forest nature conservation. This is underlined by the fact that many governments lack resources even for the traditional publicly financed nature conservation schemes.

This research is based on a literature analysis and a qualitative case-study of a multi-year pilot project in Finland, a voluntarity-based forest biodiveristy-value trading system "Metso". The study outlines an alternative concept for strengthening forest biodiveristy by introducing a banking-model for biodiversity-value trading. The conceptual model includes such elements as: voluntarity, intensive management and production of well-defined biodiversity values, and trading of these values accodingto cearly determined rules. Defining the biodiversity-values according to certain measurable criteria is necessary to allow pricing, quantifying, and trading the "products" or "biodiversity-value units".

The concept provides potential income generation to small and large land-owners, and fits for large and small private investors. Major pre-conditions, challenges and risks related to the success of the potential model are identified and discussed, in particular in the context of European and North European markets and conditions. However, the model may be tailored and modified to any region, presuming that the circumstances are favourable.

forest management, ecosystem conservation

Poster Exhibition Friday

70 - Improved role of forests for people through favourable forest laws and environmental legislation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3458 **Impact of new regulations to role of forests for community and the process of obtaining customary forest status**

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(1) Bogor Agricultural University, Daemeter Consulting, Bogor, Indonesia; (2) Rafflesia Research Network, Bogor, Indonesia; (3) LTS International, Nr. Edinburgh, United Kingdom; (4) Value For Nature Consulting, LTS International, Oxford, United Kingdom; (5) Daemeter Consulting, Bogor, Indonesia; (6) LP3M, Malinau, Indonesia

Abstract: Forests have important roles to community livelihood. Along with the change in the global economy, forest and environmental laws, legislation, and regulations in Indonesia also change: if not amended, repealed and replaced by new ones. Punan Adiu community has been undergoing procedures to obtain recognition from the Malinau District Government as customary law community (CLC) and the areas have been traditionally managed as their customary law territory (CLT). The objective of this study is to assess the impact of new regulations to existing forest roles for community and the process of obtaining customary forest status. Policy review and analysis on relevant laws, legislation and regulations as well as key informant interview to relevant stakeholders were conducted. Results show that the new regulation issued by the Minister of Environment and Forestry (MoEF), Regulation No. 83 of 2016 on Social Forestry (SF Regulation), has repealed and replaced four previous regulations to become a generic one. This SF regulation explain the rights of communities to manage forests under Social Forestry programs: Village Forest (HD), Community Forest (HKM), Community Plantation Forest (HTR), Forestry Partnership, and Customary Forest (HA). Especially for Customary Forest, this regulation refers to MoEF Regulation No. 32 of 2015 on Titled Forest (Hutan Hak, TF Regulation). TF Regulation has admitted the Customary Forest is not part of State Forest Area and therefore the procedures to obtain the status are similar with obtaining the status of Titled Forest. The basic requirement for this is customary community must obtain recognition from the local government (district or province) as CLC and the areas managed as CLT. MoEF must prepare for releasing State Forest Areas to become Customary Forest Areas, which likely to happen in the coming decades. Communities will have full rights to manage their forests, following the functions of the forests and regulation for each function.

customary, community, forest, policy, impact

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1303 **Institutions and procedures relevant to conduct activities in the forestry sector in Serbia and the Republic of SRPSKA**

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Abstract: The research was conducted for the purpose of knowledge acquired by reviewing relevant documents which companies are doing business in the area Republic of Srpska (RS), which is required for the establishment of companies in Agency for Intermediary, IT and financial services (AIIF) documents to be used for the purchase, processing and sales of wood products (WPs) and non-wood forest products (NWFPs). The purpose of the research is to show the relevant factors and procedures related to the way of doing business and present institutions, procedures and necessary documentation relating to the purchase, processing and placement of WPs and NWFPs in RS and Serbia. Primary data were collected through direct interviews. Institutions that are relevant for the establishment of enterprises engaged in WPs and NWFPs are: AIIF Agency, Tax Administration and Court of Registration. Documentation that is used in processing of WPs are: commercial invoice, packing list, receiving book, work order, product specification and the processing list. Institutions relevant to the issue of permits for the collection of NWFPs are: Ministry of Agriculture, Forestry and Water Management, PFE "Forests of the Republic of Srpska, the Ministry of Planning, Civil Engineering and Ecology, Institute for Protection of Cultural and Natural Heritage and National Parks. The same numbers of institutions are responsible for obtaining permits for the collection of NWFPs in Serbia and RS. In Serbia is more complicated process for getting permissions compared to RS.

institutions, Republic of Srpska, procedures

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IUFRO17-927 **How local stakeholders developed a customary forest scheme in Jambi, Indonesia**

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Abstract: Customary forests (CFs) in Indonesia have been legally regarded as state forests under forestry law, which resulted in increasing conflicts throughout Indonesia. Yet, the local government in Kerinci district, Jambi province has recognized CFs through governmental decrees for more than 20 years. While ministerial regulation in 2015 decided to exclude CFs from state forests and gave property rights to local communities, there are still few cases in which such forestry is formally recognized by the government. Thus this study investigates how local stakeholders such as residents, NGOs and local governments have interacted and developed CF schemes in Kerinci. Through interviews with stakeholders and document analysis, we found that the establishment of the Kerinci Seblat National Park (KSNP) was a landmark for recognition of CFs by the local government in Kerinci. As a part of the program for KSNP, WWF started developing the CF scheme by cooperating with local governments and local citizens to create joint regulations based on local customary laws. Activities for CFs such as patrol and plantation by local people have succeeded through the support of local NGOs up to now, which shows the cooperation of multi-stakeholder is indispensable for successful local CF management.

Indonesia, Customary forest, Local government, NGO

Poster Exhibition Friday

70 - Improved role of forests for people through favourable forest laws and environmental legislation

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IUFRO17-1663 **Basis for the State Forest Policy in form of the Czech National Forest Inventory**

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Abstract: In the Czech Republic, two cycles of the National Forest Inventory (NFI) were implemented so far, the first one in 2002-2004 and the second one in the period of 2011-2015. Both cycles were executed by the Forest Management Institute, Czech Republic. The created database fulfills an essential condition for the decision-making at national and regional level, where objective sources of information and reliable evidence is necessary. Objective finding of the real state and development of forests should be the basic principle of the state forest policy and it should serve for future decisions - the reason behind NFI projects.
The aim of the national forest policy is sustainable forest management. For this reason the NFI must be able to answer the question if there are forests in the Czech Republic used according to the principles of sustainable management and thus there is not a degradation, lack of fulfillment of production or ecological and social functions.
This contribution presents the analysis of the results of the NFI and their comparison against the current databases containing information on the forests state and development surveyed by summarization of the forest management plans. The results confirms the hypothesis that the state of the forestry policy in the Czech Republic should be adjusted. Processed results of the NFI will also be used for the needs of all relevant sectoral policies (environmental policy, energetic policy, rural development, water management policy etc.). The use of the NFI could be an inspiration for the other nations when revising existing national forest policy or creating new ones.

National Forest Inventory comparison forest policy

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IUFRO17-2357 **Regulatory framework of forestry and related sectors addressing climate change mitigation in European Union and selected southeast European countries**

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Abstract: This paper presents analysis of climate change mitigation in regulatory (strategic and legal) frameworks of forestry and related sectors in European Union and selected Southeast European countries (Slovenia, Croatia, Federation of Bosnia and Herzegovina and Serbia).

Comparative method and content analysis have been used. Interviews with the representatives of public administration, services and organizations in the sectors of environment and nature conservation and forestry have been used for primary data collection. The analysis included the attitudes of respondents towards the regulatory framework related to climate change mitigation, and toward the needs for the framework improvement through integration of climate change issues into sectoral policies. Strategic and legislative documents of forestry and related sectors have been used as a secondary data.

The impact of forestry on climate change mitigation has been reviewed through: replacement of non-renewable energy resources by biomass, CO2 sequestration and use of wood products. The role of forestry in reduction of greenhouse gases, importance of biomass and wood products use is emphasised by strategic documents of the sector. In addition, there is clear recognition of the possibilities for the influence of legislative framework of forestry and related sectors through defined goals in all selected countries.

climate change, forestry, policy, EU, SEE region

Poster Exhibition Friday

25 - Food-trees in forest and farmlands: improving livelihood of communities in tropical regions

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1734 **Uses of Bombax costatum (Malvaceae) in the surronding villages the Pendjari Biosphere Reserve**

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Abstract: The red kapok tree, Bombax costatum is a common tree species found in the Sudanian zone of Africa. It is poorly studied and underutilized. This paper assessed knowledge on the uses of B. costatum among different socio-cultural groups, age and gender categories. Data were collected in the Pendjari Biosphere Reserve over one hundred and eighteen informants that were surveyed using individual semi-structured interview and direct observations. Quantitative ethnobotanical indices were computed. 46 uses were recorded and grouped in eight categories of use (food, handicraft, wood, worship ritual, ecological assets, material, medicine and socio-culture). Food (RFC=0.90), medicine (RFC=0.87), material (RFC=0.28) and cultural (RFC=0.24) were the main reported use categories. Leaves, bark, seeds and roots were the most used organs for food, medicinal, and cultural purposes. There were differences among socio-cultural groups, but neither between men and women nor among age categories. Berba and Peuhl groups use B. costatum for ecological and religious purposes while Waama and Natimba use it for food and timber purposes. However, studies on propagation methods are still needed to guide domestication strategies of the species.

Bombax costatum, uses, radar chart

KG II - HS 2121 (Uni Freiburg)

IUFRO17-44 **Diploknema butyracea: A viable livelihood option for hill communities of Central Himalayan Region**

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Abstract: Diploknema is a small genus (Family: Sapotaceae) of trees distributed from India to Philippines. The species is distributed from Kumaun eastwards to Sikkim and Bhutan (sub Himalayan tracts and outer Himalayan ranges) and it also occurs sporadically in tropical moist deciduous forest. It has been reported from Andaman Islands where it is frequently found in semi-deciduous and evergreen forests. The trees occur chiefly along the sides of ravines of hills and in shady valleys. It is found in the elevation range between 300 to 1500masl. The species is promoted on the margins of agricultural fields as a fodder tree. Besides the fruit which is a valuable staple food; flowers constitute bee forage during winter months and utilized for the preparation of jaggery and spirituous liquor. Both traditional as well as modern methods are used for production of "Cheura honey" which is beneficial for health. The kernels of cheura yield edible oil, known in the trade as "Phulwara Butter" which has been classed along with commercial Morwa bassia fats. The fatty oil extracted from the D.butyracea kernels in an important article of commerce. Its seed oil is being used by hilly range people for their cooking purposes.
Keeping the above facts in view, the present study was undertaken to evaluate the nutritional aspects as well as phytochemical analysis of cheura seeds to develop value added products. On the basis of recommendations, farmers can opt for the oilseed as cash crops and they can get good monetary return from D.butyracea crop production, which make enable them to achieve the sustainable livelihood and have tremendous potential to boost the economy of the rural population.

Diploknema butyracea, livelihood, Oil

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1480 **Promoting Value Chains for three important Non-Timber Forest Products to support Biodiversity Conservation in Benin**

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Abstract: NTFPs commercialization has been recognized for its contribution to poverty reduction through increased cash income of rural households and promoting forest conservation. However, this couldn't be done without good organisation of their commercialization. This study assessed marketing system of V. paradoxa, P. biglobosa and A. digitata seeds in Benin and formulated recommendations for their sustaible use. Data were collected from 161 actors (87 harvesters and 74 traders). Most of harvesters sell their products (seeds) locally at their house. Markets information are not equally shared within the commercialization channel; traders are more informed on price than harvesters. The main commercialization mode is individual cash sale but buying through advances payment was observed. The large part of products collected were sold without any transformation. Market performance indicators reveal that price evolution depends on the periods and avalaible quantity of seeds at the market. Retailers and wholesalers seem to have the highest net marketing margin in the system. Governance structure in the marketing system is market type; relationship between the actors and the prices are fixed by the market which is open and where reign competition. Actors's perception about these NTFPs marketing sustainability varies according to the facility to get seeds and their experience in this activity. Sustainable harvesting and traditional agroforestry systems development are the main conservation strategies developed by commercialization actors. People's sensitization about law which regulate exploitation and exportation of NTFPs in general could contribute to sustainable resource management and poverty reduction.

NTFPs - Value Chains - Poverty reducing - Benin

Poster Exhibition Friday

20 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2571 **The Role of Forests: Geographical Positions, Context and Self -Perceived Vulnerability**

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Abstract: Increasing levels of deforestation in developing countries including Malawi has contributed to fatal floods through flash floods. Environmental degradation in highlands is causing excessive soil erosion leading to loss of farmlands and excessive run off during the rainy season. Smallholder farmers living in Middle Shire areas lose their farmland due to heavy rainfall and excessive run off. On the other hand, smallholder farmers living in Lower Shire areas experience fatal floods, lose lives, farmland, assets, and livestock, with more damage to infrastructure. The aim was to understand the relationships between forests, runoff and floods in different geographical areas, contexts and perceived vulnerability. Data was collected through 227 household interviews, 57 in-depth interviews with key stakeholders, 12 focus group discussions with communities and participant observations. The role of forests in flood prone areas go beyond mitigating flash floods to saving lives. Trees in Nsanje, Malawi are used as means to escape being swept off by floods and hence save lives. Flood victims appreciate the first ever unique role of trees and are willing to invest in more afforestation projects. In the Middle Shire however, communities are willing to plant more trees to protect their farmlands through protecting the top soils. The different contextual perspectives needs to be understood to design effective forestry projects and programs. Understanding the role of trees in different areas, with different contexts will contribute towards enhancing environmental sustainability and sustainable development.

Forest, context, perception, vulnerability, floods

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3256 **Do forest conconcessions benefit extractivist communities? The case of the Jumari National Forest**

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Abstract: Public forests are one of the keys to the sustainable development of traditional communities. However, when poorly managed they fail to fulfill their environmental, social and economic functions. In this context, a policy of forest concessions proposes the use of forest resources through low impact management. The first case to implement such a policy in Brazil was the Jamari National Forest. This study sought to analyze the commercial potential for harvesting non-timber forest products in Forest Management Unit III by the communities around Jamari National Forest. The present study used production data for both Acai and Brazil nut by traditional communities, "Am érico Ventura" and "Linhas 113-119". Data analysis and interpretation was performed using socioeconomic indicators and indexes based on the methodology of the Project for the Economic Analysis of Basic Systems of Rural Family Production in the State of Acre. The main results suggest a potential income stream of R$ 3,320.27 per person for açaí crop and R$ 817.84 per person for the Brazilian nut harvest, which could benefit a total of 129 harvesters, during the crop season. We concluded that these products could be produced in partnerships with the forest concession enterprises and thus contribute to the sustainable development of the surrounding communities.

Forest Policy; Forest Concession; NTFP

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IUFRO17-1489 **Farmers' motivations to plant and manage on-farm trees in Ghana**

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Abstract: Deforestation and continuing degradation of existing forest resources, especially in the agricultural landscapes, are serious threats to the sustainability of the timber industry in Ghana. Planting trees on farms has been identified as having great potential to increase timber supply from agricultural landscapes to bridge the gap between timber demand and supply. This study examined farmers' motivations and behaviours to engage in on-farm tree planting and management in Ghana by combining internal and external factors in a socio-psychological model. Data were collected from 156 smallholder farmers from five communities in Asankragwa and Sefwi Wiawso forest districts in Ghana using pre-tested semi-structured questionnaires. Additional farm inventory data were collected from 33 farmers under two on-farm tree planting schemes. Farmers viewed on-farm tree planting as economically beneficial. On-farm tree planting was perceived as providing income, access to personal wood for furniture, and access to loan facilities. Incentives in the form of provision of grants, farming inputs, seedlings, capacity training, and access to markets for agricultural produce are factors that motivate on-farm tree planting in Ghana. The average standing volume of on-farm trees in the study area is 51.9 m^3 ha^{-1} which is higher than the national average for the off-reserve areas in the semi-deciduous forests to which much of the study sites belong. Many farmers considered high financial costs and low knowledge of proper techniques in managing planted trees in agricultural production systems as barriers to the development of tree stock on farms. On-farm tree planting programmes are more likely to succeed if the programmes incorporate policies that acknowledge and address motivational factors and barriers which underlie farmers' reasons for engaging in on-farm tree planting.

Farmer motivation, decision-making, agroforestry

Poster Exhibition Friday

89 - Reviving policies and practices for multiple-use production forestry

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IUFRO17-2869 **Integrative indicator for optimizing forest policies**

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Abstract: To fulfil sustainably all demands of the society, forest policies and governance must adapt to ever emerging social needs and values. The indicator proposed here is a criterion to optimize forest policies. It is based on an innovative mathematical theory, developed for this purpose. The theory uses linear algebra, statistics and discrete analysis, in order to integrate all forest outputs, perceived as important by at least one actor, into an indicator. Problems raised by the heterogeneity of the outputs are solved using vector-based mathematics. Outputs are considered as vectors with an unknown number of dimensions but with known modules (lengths). Statistical methods and discrete analysis methods are used to compute the length of a resultant vector which represents the optimization criterion. The criterion measures the effects of change on forest outputs and is used as a feedback to improve forest governance. The indicator can integrate any available data, in an iterative manner. The holistic-integrative indicator has the potential to improve forests-society-science-policy-practice functional networks and to operationalize the concepts of natural capital and ecosystem services as well as to provide the means for a more sustainable and integrated multiple-usage of World's forests. It also ensures transparency of the forest policies.

inclusiveness, equitability, multi-actor approach

Poster Exhibition Friday

51 - Forest management strategies to enhance the mitigation potential of European forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-937 **Adaptive forest management to account for climate change impacts: review and options for the Netherlands as case-study**

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Abstract: Adapting forests to climate change is one of the major challenges for forest management in the near future. The aim of this study is to give an overview of the current state of knowledge on the main responses of Dutch forest to climate change and to identify options for managing these forests in the face of climate change. This adaptive forest management in case of the Netherlands has two main objectives: 1) to maintain forest productivity in order to meet the growing societal demand for a wide variety of different ecosystem goods and services, such as timber production, biofuel and biodiversity, but also 2) to increase forest resilience against adverse effects such as drought and storms.

The study focusses on the main forest types in the Netherlands, growing in large part on relatively dry site conditions. In this context, the main silvicultural interventions are adapting stand density and changing species composition. Thinning has proven to be an effective measure to release target trees from competition for resources, so adjusted thinning rules may help maintain stand productivity by reducing transpiration surface while increasing throughfall and thus soil water availability, thereby enhancing resilience to drought.
The relevance of promoting the establishment of mixed stands is manifold. Managing mixtures fits well in the Dutch silvicultural approach that aims to promote higher biodiversity and is increasingly nature-based. In some specific cases higher productivity has been documented in mixtures. Mixtures may provide additional (drought) resilience of a forest, depending on species and admixture proportion. This review presents an overview of both thinning and adapting species composition as part of adaptive management in the Netherlands.

forest growth, drought, mixtures, thinning

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3422 **Assessing carbon storage potential of black locust in Poland basing on data from National Forest Inventory**

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Abstract: Observations and measurements in Polish NFI are carried out on permanent sample plots. NFI covers all forests in the country despite of the ownership and stand age. All measurements are taken during a 5-year cycle. Empirical allometric formulas allow for determination of dry biomass of trees and their components on the basis of tree characteristics (usually diameter or height and diameter). Formulas for stem, leaves and branches dry biomass for black locust, based on 36 sample trees at different ages, collected in West Poland in stands growing on different site conditions, were developed. To assure the logical assumption of additive character of those formulas, seemingly unrelated regression was used for the final formula determination. The developed equations were used for dry biomass calculations for black locust in Poland using more than 100 NFI sample plots. Based on "IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual" it was assumed that carbon constitutes of 50% of dry biomass. Local empirical biomass equations allowed us to calculate biomass amount and carbon storage for analyzed tree species with high accuracy and to compare the results with potential of other species, including the most prevalent one (Scots pine) and occupying similar sites.

Black Locust, biomass, carbon, NFI

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2733 **Developing an atlas of forest management practices in Europe**

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Abstract: Forests provide a range of ecosystem services to society and the provisioning of these services can be affected by management practices. Forest management practices vary across Europe. In some regions forests are managed with the main objective to produce wood, while in other regions forests are managed for other objectives. While broad patterns in management practices are known, the practices applied in European countries are generally poorly documented. The aim of our study was to develop an atlas of forest management practices in Europe.

We compiled information on forest management practices from a survey on the conservation and sustainable use of forest resources, a database on forest management practices and a set of country-specific narratives on forest management practices during the 20th century.

The results of our compilation provide information on (i) how European forests are managed, (ii) the dominant forest management regimes in Europe and (iii) how forest management has changed since the mid-20th century. These results improve the knowledge basis to better understand how regional differences should be taken into account when developing forest policies. Such understanding is indispensable for example to target climate change mitigation and adaptation efforts in the European forest-based sector.

Poster Exhibition Friday

51 - Forest management strategies to enhance the mitigation potential of European forests

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IUFRO17-1708 **Economic optimization of the rotation age of stands - case study of carbon accumulation and timber production**

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Abstract: Central task of the report is choose the age at which stands of growing timber should be harvested. The choice determines how long each stand must continue to earn interest, and also determines the size of the total inventory that must be to sustain the annual harvest. It is a problem that calls for analysis of biological as well as economic relationships over time and has intrigued economists for more than two centuries. The method of determining the rotation age depends primarily on the objectives and management practices (e.g. timber production, carbon accumulation), which determine the optimal age of trees and stands for felling. It includes the methodological basis of optimization of the rotation age of stands due to the maximization of the accumulation of timber and carbon production in the tree stands.
The report analyses the timber and carbon production function depending on rotation age, growth, cost and other characteristics of forest, as well as the costs of land. The prerequisite for achieving the economic optimum of the rotation age of a stand is to balance the current increase in the total timber production value (growth and yield) and the value of opportunity costs from delaying cutting till the next year. This report demonstrates how this economically optimum rotation age can be calculated, and how it varies according to the biological growth and economic parameters of the forest.

timber, carbon, value, growth, costs

Poster Exhibition Friday

135 - Linkages between carbon sequestration and nutrient and water use efficiency in forests.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-886 **15-year dynamics of Nitrogen Use Efficiency (NUE) in Pinus sylvestris forests in the Southwestern Pyrenees, Spain**

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Abstract: European forestry is experiencing important changes in climate, biodiversity and management, demanding new approaches to manage Scots pine forests. We used inventory data from two Scots pine-dominated sites in the Southwestern Pyrenees: one is a high-elevation (1335 masl) continental/subalpine site, while the other is a low-elevation (635 masl) Mediterranean/montane forest. At both sites, thinning trials (20-30% basal area removed) were carried in 1999, and at the Mediterranean site again in 2009 (20-40% basal area removed). We calculated the nitrogen use efficiency (NUE) for the past 15 years, and its components (annual nutrient productivity [A], and mean residence time [MRT]). We found that there is higher NUE in the high elevation site than at the low elevation site. Thinning treatments do not have a significant effect on NUE at any site, but in the Mediterrean site thinning increased A and reduced MRT. As trees grew older, NUE has not changed at the continental site but it has decreased at the Mediterranean site. At both sites A has decreased whereas MRT has increased, indicating that trees are trying to use their nitrogen longer. Our results indicate that the strategies to use nitrogen are different between sites, and also change over time.

Pinus sylvestris, nitrogen use efficiency (NUE)

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1091 **Dendroecological approach reveals climatic drivers of carbon sequestration in Mexican forests**

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Abstract: Forest ecosystems are the major biological scrubber of atmospheric CO2, capable of mitigating large amounts of carbon dioxide. Nevertheless, several studies around the world report that ongoing global climate change would alter forests, from composition to structure. There is still no consensus regarding the use of specific techniques to quantify climatic drivers in species carbon models to investigate the ability of biodiverse forests to sequester carbon. Such models can help to determine ecosystem productivity and infer the relevant ecological processes that species are facing in terms of climate variability.
Therefore, from a long-term perspective, conifer forests in Mexico represent an opportunity to increase our understanding of carbon dynamics in sites where multiple ecological mechanisms are involved. We characterized the carbon uptake dynamics using a dendroecological approach in a hotspot of pine diversity, the Sierra Madre Occidental in Mexico, and we evaluated the influence of climate (precipitation and temperature) on tree-ring width (radial growth), wood density, and carbon accumulation.
We found that radial growth and wood density are influenced by climatic drivers in northern Mexico, and that species-specific variations in carbon uptake responded differentially to specific climatic drivers. Overall, the ring-width chronologies and wood-density chronologies showed strong correlations with precipitation and temperature, respectively. In particular, our results showed that low precipitation and high temperature led to substantial losses in carbon accumulation, which is evidence of the vulnerability of these conifer forests to climate change and environmental shifts.
We found that this approach provides a suitable basis for modeling projections of the long-term carbon balance in terrestrial ecosystems.

Climate change; Carbon dynamics; Tree-ring.

Poster Exhibition Friday

68 - Forest Adaptation and Restoration under Global Change

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IUFRO17-2280 **The effects of climate change and species mixture on survival times of forest tree species**

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Abstract: Distribution, productivity and mortality determine the suitability of a tree species at a given site. There are a lot of studies about the effects of climate change on species distribution or productivity, whereas much less is known about how mortality dynamics will be affected by climate change. We investigate mortality dynamics of Germany's most important tree species (Norway spruce, European beech, Scots pine, Silver fir, Pedunculate and Sessile oak, Douglas fir) by applying survival analysis to combined German and European crown condition data (Level I) and data of intensive monitoring sites (Level II). In order to predict changes in survival probabilities under future climate scenarios, it is essential to cover the warm and dry distribution edges of the species. We aim at identifying the most important environmental influences on mortality by investigating climatic parameters, topographic indices and soil parameters. Besides environmental conditions, forest management and mixture of species are assumed to have an important influence on survival times. We tested the suitability of various types of survival models for Level I and Level II data. The final survival model explains survival times in dependence on environmental conditions and stand characteristics. Estimated survival rates can be used to assess the economic risk under climate change.

survival analysis, mortality, forest inventory

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2930 **Climate change at upper treeline: How do trees on the edge react to increasing temperatures?**

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Abstract: Treeline ecotones are thought to be particularly sensitive to climate warming, and an alteration of their growth conditions may have important implications for the ecosystem services they supply in many mountain regions.

We use a novel approach to quantify effects of a changing climate on tree growth, using case studies in the European Alps. We compiled tree-ring data from almost 600 trees of four species at treeline in three distinct climate regions of Switzerland. To assess the influence of temperature on annual growth, we used linear mixed effect models (LMMs), allowing us to quantify effect sizes and to account for between-tree growth variability. After removing biological growth trends, we isolated temporal trends of ring-width indices (RWIs).

For all species, climate-growth LMMs indicated strong positive responses of RWIs to temperature in early summer and previous year's autumn, featuring considerable between-tree variability. All species showed positive RWI trends at treeline but different interactions with elevation: *Larix decidua* exhibited a declining RWI trend with decreasing elevation, whereas *Picea abies*, *Pinus cembra* and *Pinus mugo* showed increasing and/or stable trends. Not only may our findings reflect the effects of ameliorated growth conditions on tree growth, they might have also revealed suspected negative and positive feedback effects of climate change on treeline stand dynamics.

Climate change, treeline, growth increase

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3457 **Winter warming: harmful effect of changing snow conditions on tree seedlings in the boreal forest**

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Abstract: Frequency of rain-on-snow events and winter warm spells is increasing in high latitudes and is forecasted to further increase in the future. By decreasing the insulation capacity of the snowpack and causing ice layers or ground ice encasement (IE), those events have the potential to lead to colder soil but also to hypoxia and accumulation of trace gases in the subnivean environment. To test the effect of such changing overwintering conditions on boreal forest, we established a snow manipulation experiment in a coniferous forest in Northern Finland with planted Norway spruce and Scots pine seedlings. Four snow manipulation levels were applied: ambient conditions, artificial IE, snow compaction and complete snow removal. Deeper soil frost during winter was only observed after complete snow removal. Hypoxia and accumulation of CO2 in soil were highest in the IE plots but, more importantly, the level of 4% CO2 was exceeded for 45 days in IE plots whereas it was not reached in ambient conditions.
After one winter of snow manipulation, IE led to sharp decreases in the proportion of healthy seedlings. Treatments affected the non-structural carbohydrate concentrations in above- and below ground parts in spring, with reduction of current shoot growth at the end of the following growing season.
To understand the mechanisms underlying the damages observed by the different snow conditions, Scots pine samples collected after two winters of snow manipulation have been analyzed at the physiological, biochemical and molecular levels. The result of the expression of 30 marker genes involved in stress response and primary metabolism will be presented; they suggest a treatment effect on some carbohydrate and specific stress-related genes.
Our results demonstrate a negative impact of winter climate change on boreal forest regeneration and productivity.

winter warming, snow, CO2, ice encasement, conifer

Poster Exhibition Friday

68 - Forest Adaptation and Restoration under Global Change

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2011 **Bioclimatic modelling and environmental tolerance to global change in strawberry tree**

Ribeiro, M. M.* (1); Roque, N. (1); Ribeiro, S. (2); Albuquerque, M. T. (3); Gavinhos, C. (1); Quinta-Nova, L. (1)

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Abstract: The strawberry tree (*Arbutus unedo* L.) has potential to be successfully businesslike-cultured for a broad area in Portugal, but remains largely a neglected crop. This region shows a particular sensitivity to global warming, which brings together the reduction of precipitation rates and, consequently, a long-term negative effect on vegetation.
To investigate the interactions between the species' distribution and the related ecological factors, a 319 plots (1-Km grid level) dataset was used, where 8 ecological attributes were characterized: ombrothermic index (OI), thermicity ndex (TI), continentality index (CI), pH, organic matter (OM), sand, topographic position index (TPI), number of fires (NF) and burned area (BA).
The obtained matrix was firstly analyzed through PCA to reduce the space of analysis and to detect patterns within the dataset and possible collinear covariates. The PCA output stresses the importance of climatic attributes, namely the OI and the TI, which show a strong inverse correlation.
The effect of current and future climate attributes on the species' distribution was obtained through stochastic modeling. Two representative concentration pathways (RCPs) scenarios (RCP 4.5 and RCP 8.5) were fitted for 2050 and 2070. The predicted outputs were compared with mean image for current climate conditions. A set of four bioclimatic variables (WorldClim v 1.4) were used: the annual minimum and maximum temperature, the annual precipitation and the precipitation of driest month. The MaxEnt software allowed spatial interpolation using the 319 1K plots. The predicted results revealed an area reduction of the species' potential in the Southern regions and an increase in the Northern ones. Considering a probability of occurrence > 50%, until 2050, for the RCP 4.5 and the RCP 8.5 scenarios, the species' potential area reducition is about 76% and 78%, respectively. Until 2070, the total expected reduction is of 80% and 82%, for the same RCP scenarios respectively.

Global change;MaxEnt; multivariate statistics.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3464 **Trade-offs between climate change adaptation and mitigation objectives in Germany**

Saha, S.* (1); Bauhus, J. (1)

(1) Chair of Silviculture, University of Freiburg, Freiburg, Germany

Abstract: Significant trade-offs may exist, if the conditions that maximize standing volume do not support high levels of species and structural diversity. We aimed to quantify achievements and trade-offs between the mitigation (standing volume) and adaptation objectives (structural and species diversity) for a wide range of forest types in Germany. For example, the achievement of an objective at a given inventory plot was quantified as the relative deviation from the mean for a given forest type. The trade-off for one objective was defined as the standardized difference from the overall achievements of all objectives for that forest type. We synthesized data from the German forest inventories to capture the changes in trade-offs between the management objectives over a gradient of site productivity, water availability, and harvesting intensity. Trade-offs between objectives were influenced by harvesting intensity, forest composition, water availability, tree size, and species identity. Mixed forests had higher achievements in species diversity as well as high trade-offs between diversity and stand biomass compared to monospecific forests. Achievements in structural diversity increased with tree size. However, it was varied between forest types. We showed for the first time; that significant trade-offs exist between climate change adaptation and mitigation objectives for German forests.

Adaptive management; National Forest Inventory

Poster Exhibition Friday

32 - Perspective of short rotation forestry for sustaining society and environment

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1936 **Establishing Short Rotation Coppice on Marsh-Grassland**

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Abstract: In 2013 and 2014, the Bavarian State Institute of Forestry set up experimental plots of short rotation coppice on grassland. The aim of the project was to establish poplar-SRC plantations without ploughing and tilling, and without using herbicides. Furthermore, productive SRC plantations were needed to supply the estate administration's heating system with woodchips.
The analysis of the collected data shows that the establishment of SRC plantations on grassland cannot succeed without weed control. By contrast, a bio-degradable foil used carefully to eliminate weed competition will ensure the success of the plantation. The cultivating of the planting rows, especially in combination with mechanical weed control, increases the survival rate of the cuttings too. On the other hand, conventional SRC plantations, in which the soil was ploughed and tilled prior to planting and moderate use was made of herbicides, showed higher survival rates for the cuttings and a higher yield in the first few years.
As alternatives to the foil and cultivating of the planting rows to preempt weed damage, the project tried out the planting of one- and two year-old poplar live stakes, and black and grey alder were planted. Both methods are more costly, but were successful. As natural trees, black and grey alder do of course also have a higher ecological value on these sites of considerable importance in terms of nature conservation.

Bio-Energy, Woodchips, SRC

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3642 **Eucalyptus grandis trees growth: Effects of nutrition and water availability and interactions with the environment in a prolonged drought period**

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Abstract: In the context of climate change, survival and productivity of eucalyptus plantations are affected by prolonged drought periods. We evaluated the effects of forest nutrition (with K and Na compared to control) and water availability, and their interactions, in a real prolonged drought scenario (occurred in 2014) on the growth of Eucalyptus grandis trees in Brazil. In a split-plot design installed in June 2010, we evaluated trees submitted to two water regimes (without rainfall exclusion and with 37% rainfall exclusion) and three fertilizer supplies (K, Na and control). The stem diameter increment was measured every 15 days with dendrometer bands and total height, every 6 months in the period from 40th to 61st month. Soil moisture was analyzed weekly and precipitation and temperature daily. The results indicated that nutrition with K showed a higher growth rate; with Na, trees had an intermediate growth rate between K and control treatments. With the artificial exclusion of 37% of throughfall there was a negative effect on the increment growth of K fertilized trees; but in the control and Na treatments the rainfall exclusion showed no significant effect until 58° month. Rainfall influenced significantly the increment growth of the trees, followed by the minimum temperature and soil moisture. K and Na showed interaction with precipitation according to seasons: during dry season, by reducing the growth of the tree trunks with Na and its stoppage with K, and during the rainy season, with increasing growth in diameter and height of the trunk for both K and Na, compared with the control. It is shown the importance of including K in basic fertilization for higher productivity of Eucalyptus forest plantations, however in regions that are more arid and with a greater risk of prolonged drought, potassium and sodium could increase the drought effect.

Climate change, Water deficit, Forest nutrition

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2512 **Growth rate variations of Eucalyptus camaldulensis: a comparison between systems - monoculture and silvopastoral system**

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Abstract: RIGHI in research developed since 2009 has proposed a three-dimensional agroforestry systems (AFS) model in order to provide a greater canopy exposure to solar radiation and higher growth. In this sense, a controlled planting time sequence would provide a controlled canopy roughness. This study aimed to analyze the Eucalyptus' DBH (diameter at breast height) and biomass increase rates in a silvopastoral system (SPS) related to its monoculture. The experiment had four randomized blocks containing three treatments each: 1. Witness (monoculture); 2. SPS2 with distance between rows of 24 m and; 3. SPS3 with distance between rows of 42 m. The trees were planted in October/2011 being annual inventories performed from 2015 to 2016. Monocropped trees presented an incremental DBH rate of only 1.42 cm.tree-1.year-1. In contrast, trees in SPS2 presented an increase of 1.94 cm.tree-1.year-1 and of 2.56 cm.tree-1.year-1 in SPS3. That means Eucalyptus in SPS3 grew 80% more in diameter compared to those in monoculture. Regarding biomass, trees in monoculture increased by 49 kg.tree-1.year-1. Trees in SPS2 presented an increment of 99 kg.tree-1.year-1 while in the SPS3 presented a growth rate of 128.5 kg.tree-1.year-1 an increase of 161% more than those in monoculture. Trees in SPS(2 and 3) presented a tremendous increase in DBH and biomass accumulation compared to those in monoculture. Planting trees in SPS is a way to produce them with a larger DBH in shorter time increasing timber value for the same volume.

production; agroforestry; trunk diameter; biomass

Poster Exhibition Friday

32 - Perspective of short rotation forestry for sustaining society and environment

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3494 **Group planting fosters better growth and superior tree quality compared to conventional row planting: The first study on wild cherry trees (Prunus avium L.) from Germany**

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Abstract: The survival rate, growth, and tree-quality of fast growing cherry trees were compared between group and row planting. The influence of neighbourhood competition and light availability on growth and quality was studied. A trial was established at a wind-thrown site in southwestern Germany in the year of 2000. The survival rate, diameter, and height were significantly higher in group planting. The proportion of cherries with straight stems was 40.5 % in groups compared to 15% in rows. 13.5% of cherries had monopodial crown in groups compared to only 2% in row planting. The proportion of dominant cherry trees in canopy was 49% in groups compared to 22% in rows. The length of branch-free bole was significantly higher in cherries from groups than those in rows. Neighbourhood competition reduced the growth and stability of cherries in row planting, but, not in group planting. Light availability did not show any significant effects on growth and quality. This first study on cherry group planting indicates that the survival rate, growth, and tree quality were higher in groups than in rows at this early development stage.

Group planting; Regeneration silviculture

Poster Exhibition Friday

75 - The nexus between bioeconomy and forest biomass: Challenges, opportunities and necessary steps in

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2982 **Development of potential new products, processes and markets from secondary metabolites of Uruguayan native forest trees: advances and perspectives**

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Abstract: In a period of almost three decades, Uruguay built a forest industry based on fast-growing and short rotation eucalypts and pines plantations, beside a policy planned native forests conservation. The government is currently boosting a transition to a bioeconomy that considers the potential of new products, processes, supply chains and markets conformation of both plantations and native forests. Secondary metabolites of native trees hold historically a great potential as non-wood forest products but have remained poorly investigated. This work presents advances in bioprospecting, identification, separation and chemical characterization of secondary metabolites of three forest trees, as raw materials for innovative non-wood forest products. The research initiated in 2013 through an agreement between the National Agricultural Research Institute and the Faculty of Chemistry of the Republic University of Uruguay. The activities focused on: (i) the bioprospecting of three species (Prosopis affinis, Prosopis nigra and Quillaja brasiliensis) and (ii) the identification and chemical characterization of selected secondary metabolites. Chemical analysis were realized using HPLC and mass spectrometry. Saponins, galactomannans and alkaloids were separated and characterized at laboratory scale. The next steps point to biomass production to enable an industrial pilot scale phase and economic studies on supply chains and markets conformation.

new products, secondary metabolites, Uruguay

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2134 **GIS-based approach for land suitability of fast growing tree-energy plantation in degraded land, Thailand**

Haruthaithanasan, M.* (1); Supamitmongkol, W. (1); Tanavat, E. (1); Poolsiri, R. (1)

(1) Kasetsart University, Ladyao, Thailand

Abstract: This study determined the study area as soil degradation area without irrigation system, exclude the area which is located in the six economic crops (Rice, Corn, Sugarcane, Cassava, Para-rubber tree and Oil palm) land suitable map to avoid land competition. Land suitability was evaluated by geographic information technique with weighted sum method.
The land suitability of total potential area was classified into 4 categories, good, fair, low and not suitable, at 22.05%, 77.51%, 0.26% and 0.18%, respectively. From the mathematic model under the hypothesis of production condition, cost and benefit analysis, Eucalyptus genus is the most suitable for recommending to farmers. However to mitigate impacts which may occur from monoculture for examples pests and diseases, other genus such as Casuarina, Leucaena and Acacia were recommended to mix in the plantation. Moreover, agroforestry system was also the good practice to reduce those impacts, and instantly implement to farmers in the potential areas.

GIS, Land suitability, Fast growing tree, Thailand

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2264 **Performance of dry zone Acacia for biomass energy in degraded soil in northeast, Thailand**

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(1) Kasetsart University, Ladyao, Thailand

Abstract: Six species of dry zone Acacia (Acacia auriculiformis, A. plectocarpa, A.leptocarpa, A. brassii, A. difficilis and A. holosericea) were grown in the Randomized Complete Block Design in Manchakiri plantation, Khon Kaen province, northeastern Thailand since 2013. The objective was to screen suitability of species that might have potential to grow for energy plantation in degraded soil. Results up to 2.5 years of age in terms of survival rate, growth and biomass yield showed considerable differences between species. Survival rate of most acacias except A. plectocarpa and A. brassii were more than 80%. For total biomass among six acacias, A. auriculiformis showed highest yield (27.9 ton/ha) while A. plectocarpa provided lowest biomass yield (12.9 t/ha). Important biomass properties such as heating value, ash content, sulfur and chlorine content were analyzed to determine the suitability for using as biomass solid fuel. All acacias showed high performance of heating value between 4,134 - 4,585 kcal/kg with low ash content (0.6 - 1.9%), low sulfur (0.06 - 0.12%) and chlorine (0.01 - 0.02%). The results have implications for selection of most potential species of dry zone acacias which are suitable for degraded soil to provide biomass yield as alternative energy source. Financial analysis should be included to provide significant decision for future extension work in this degraded area.

Biomass, Acacia, Dry zone

Poster Exhibition Friday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-1707 **The influence of harvesting intensities on structural diversity of forests in SW-Germany**

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Abstract: The requirement of sustainable forest management to maintain or improve forest biodiversity is currently not supported by effective monitoring tools that can be integrated in existing forest inventories. This apparent lack is a severe deficiency, in particular when considering that in some parts of the world harvesting intensities should be increased to support a growing bioeconomy sector. Here, we followed an approach using structural diversity of forest stands as a surrogate of the provision of habitat and thus biodiversity. Based on National Forest Inventory data, we developed an index to quantify structural diversity of forests in Baden-W ürttemberg, Germany, comprising 1.3 million ha and a variety of forest types. The forest structure index (FSI) is based on 11 variables describing different aspects of structural diversity that are combined in a simple additive way. By applying this index to broad forest types (e.g. coniferous/broadleaf-dominated stands, different stand development phases, different ownerships or stocking structures), we assessed the level of structural diversity and its change over a period of 10 years between forest inventories. Our results show that structural diversity can be monitored in an objective and quantitative way in the context of large-scale inventories like the NFI of Germany. The relationships between calculated harvesting intensities and changes of the forest structure index (for the period 2002 - 2012) indicate the intensity to which forest biomass maybe removed without adverse effects on forest structural diversity. In subsequent work we will analyse the relationship between this index of forest structure and direct measures of forest biodiversity.

structural diversity, NFI, harvesting intensity

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IUFRO17-994 **Secondary shrublands facilitate the active large scale restoration of fire-disturbed southern bog forests in North-Patagonia**

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Abstract: Seven years ago we commenced a long-term research project dealing with the study of the ecological restoration of fire-disturbed Southern bog forests previously dominated by the slow-growing, long-lived and vulnerable conifer Pilgerodendron uviferum in Chiloe Island, North Patagonia. After 4 years of small-scale restoration experiments, we developed a mixed passive-active restoration approach, based on P. uviferum cluster plantings that took into account the spatial pattern of the species. A pilot experience of this approach was experimentally applied during winter 2014 at a large-scale of 30 ha, within a matrix of burned bog forests previously dominated by this conifer. Since the dense secondary shrublands of Baccharis sp and Gleichenia sp considerably hampered the planting process, it was a relevant question whether these shrublands should be retained, or removed before planting. In order to determine the effect of secondary shrublands on the early performance of P. uviferum cluster plantings, two treatments: a) shrubland removal, and b) shrubland retention, were randomly assigned to 30 cluster plantations with 41 seedlings each (15 clusters per treatment). Our results show that after 3 years of growth, seedlings established beneath retained shrublands showed significantly lower physiological stress (Fv/Fm), and therefore higher height growth, higher vitality, lower browsing rates, and lower frost damage, than seedlings established after shrubland removal. However, seedling mortality -which was surprisingly low (~2%) - showed no significant difference between treatments. These results support, for the first time at larger scales, what previous studies about P. uviferum suggested: this species can tolerate extreme wet conditions, yet suffer from stress when grown in the open. Thus, in fire-disturbed bog forests, the retention of secondary shrublands facilitate the early performance of P. uviferum, by promoting better microsite conditions.

cluster planting, conifers, physiological stress

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3229 **From spruce to beech - disturbance and resilience pathways in southern Scandinavian forests?**

Bolte, A.* (1)

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Abstract: It is assumed that climate change will favour European beech (*Fagus sylvatica* L.) to Norway spruce (*Picea abies* [L.] Karst.) at its northern range margins due to climate change and induced disturbance events. An old-growth mixed forest of spruce and beech, situated near the northern beech margin, was studied for about an decade to reveal effects of disturbances and response processes on natural forest dynamics. We carried out analyses on both overstorey and understory dynamics of beech and spruce. This was done based on a sequence of stand and tree vitality inventories after a series of abiotic and biotic disturbances like the 'Gudrun' storm in 2005, the dry and hot summer in 2006 and spruce barkbeetle infestations from 2007 onwards. It became apparent that beech performance and growth was favoured by recent warming and its higher resistance to storm and biotic impacts. Moreover beech (understory) has a larger adaptive capacity to overstory release (68% standing volume loss) than spruce. Thus, understory dynamics can play a key role for forest succession from spruce to beech dominated forests. Disturbances display an acceleration effect on forest succession in the face of climate change. Beech is poised strategically to replace spruce as the dominant tree species at the study area. The consequences of this study for forestry in Southern Scandinavia will be discussed.

storm, drought, barkbeetle, resistance, resilience

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3026 **Planning for a new wilderness in Germany - Opportunities and challenges for forest conservation**

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Abstract: The German National Strategy on Biological Diversity (NSBD) set the goal to establish wilderness areas on 2% of the country's terrestrial surface by the year 2020. Wilderness areas of the NSBD are defined as non-dissected and sufficiently large (≥ 1000ha) areas which allow for the undisturbed course of natural processes. We conducted spatial analysis to assess the potential for forest wilderness reserves in Germany. First, we defined minimum criteria for wilderness in accordance to the NSBD and identified a wilderness scenario including areas already established in Germany as well as potential future areas required to meet the 2% goal. Second, we quantified the distribution of potential natural vegetation (PNV) within the wilderness scenario to get a proxy for representation of future natural vegetation in relation to the national PNV distribution. Finally, we developed an ecological evaluation method to score the naturalness of potential wilderness areas at the local level. Results indicate a sufficient number of candidate sites to meet the goals of the NSBD. However, the implementation of the overall wilderness scenario until 2020 is limited by the German forest property situation as well as FFH areas requiring hands-on conservation measures. Management recommendations approaching future threats for forest conservation, including invasive species, are non-existent for wilderness reserves. We suggest a system of compensation payments to increase attractiveness of wilderness for private forest owners. A wilderness implementation guideline is required to set common standards including managed buffer zones, hunting and the treatment of invasive species.

New wilderness, Germany, spatial analysis,

Poster Exhibition Friday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-4182 **Achieving a constant browsing level - mission impossible?**

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Abstract: Browsing by large herbivores is frequently perceived as one of the greatest challenges for both forest restoration and forest regeneration- especially for fir (Abies) in Europe (roe deer [Capreolus capreolus] - Abies alba), North America (white tailed deer [Odocoileus virginianus] - Abies balsamea) and Asia (sika deer [Cervus nippon] - Abies Sachalinennsis). Even though qualitative system analyses highlight the structural complexity of the system "herbivore-tree regeneration" forest management mainly focuses on limiting herbivore density to reduce browsing levels. In this study we present time series of roe deer bag records of Baden-W ürttemberg (federal state of Germany, 35.751 km^2) and Europe and show development tendencies for both the browsing level (1986-2015) and the ability to reach forest management objectives (2009-2015) of regenerating Abies alba in Baden-W ürttemberg. Although the annual number of roe deer shot persited at a high level (160,000 roe deer) the number of hunting grounds that documented a high browsing level of Abies alba decreased. Moreover the federal state of Baden-Württemberg documented a positive trend in reaching forest management objectives of regenerating Abies alba. In the context of global warming and climate variations we encourage forest management not to focus on predefined browsing levels.

browsing level, bag records, climate variations

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3000 **Impacts of forest management regimes on multiple functions of natural secondary forests in Northeastern China**

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Abstract: A large area of low-quality natural secondary forest has formed because of unreasonable management in Northeast China. How to manage forests well and achieve its multi-purpose functions have become the emerging scientific issues. The present study analyzed the impacts of alternative management regimes for natural secondary forests (extensive forest management (FM1), target tree-based forest management(FM2), conversion to mixed broadleaved-based forest management(FM3) and nonintervention forest management (FM4)) on community structure and functions based on long-term ecosystem monitoring and plots investigation, the economic performance of forest management regimes was also compared based on the market investigation and expert interviews at Danqinghe forest farm in Heilongjiang. The results showed that (1) the numbers of woody and herbaceous plant species were the greatest in FM3 and FM2, the basal area of FM3 was 14%, 6%, and 15% larger than those of FM1, FM2, and FM4, the average diameter at breast height and average height under FM2 were significantly higher ($P < 0.01$) than those of FM1, FM3, and FM4. (2) total carbon storage was ranked in a decreasing order of FM2 (344.02t/ha)>FM4 (294.75t/ha)>FM1 (279.42t/ha)>FM3 (264.51t/ha), FM2 had the highest water content, and also the highest content of total potassium and available potassium of soil. (3) both the total value of forest carbon sequestration and the sequence of comprehensive economic value (per hectare) were ranked by FM2>FM3>FM1>FM4, the highest economic value was FM3, followed by FM1 and FM2 ,and the last was FM4 based on the simulation of 120y as one operating rotation. We concluded that FM2 can not only result in the stable community structure and the biggest timber production value, but also the largest carbon sequestration value, which is the better forest management strategy for natural secondary recovery. Meanwhile, long-term monitoring and evaluation should be conducted in the future.

forest management, biodiversity, carbon, economic

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1314 **Making space for invasive tree species? Increasing mortality of Castanea sativa in southern Switzerland in response to multiple threats**

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(1) WSL Forest Resources and Management, Birmensdorf, Switzerland; (2) WSL Community Ecology, Cadenazzo, Switzerland

Abstract: Forest ecosystems and their functioning are increasingly challenged by the propagation and colonization of invasive tree species. This process can be facilitated by stand degradation as the result of pathogens and severe drought. Sweet chestnut (*Castanea sativa*), formerly cultivated on large areas in southern Switzerland, is increasingly declining due to the combination of drought stress, pathogenic fungi (e.g. *Cryphonectria parasitica*, *Phythophtora* spp.), insects (e.g. *Dryocosmus kuriphilus*) and abandonment. Subsequently, an increase in mortality has been observed, favoring the establishment of invasive tree species such as the tree of heaven (*Ailanthus altissima*), an early-successional tree species native to China. While recent studies focused on the invasive potential of *A. altissima*, the decline of *C. sativa* has not been analyzed at a larger scale. In this study, we use extensive data from the Swiss National Forest Inventory to examine vitality and mortality patterns of *C. sativa* during the last decades (1983-2016). To this end, we develop mortality models for individual trees and quantify tree damage as a promoter of increased light availability. These measures of tree decline provide a representative estimate of the sensitivity of Swiss *C. sativa* stands to invasive, light-demanding tree species.

Invasive species, Pathogens, Chestnut, Mortality

Poster Exhibition Friday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-3878 **Landscape-moderated use of forest structures by bats**

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Abstract: Bats are considered as indicators of forest structural complexity and are frequently selected as target species for conservation programmes. Forest-dwelling bat species use old and dead trees as roosting sites, and forest gaps and linear elements for foraging and commuting. Retention of old-growth structures may be beneficial for the conservation of biodiversity, but their use and usability by bats may strongly depend on the landscape context. Species-specific association of bat occurrence with forest structures has been shown at plot scale (1 ha), however minimum landscape-scale requirements for abundance and distribution of such structural elements are lacking. Within the DFG-funded Research Training Group ConFoBi, we relate bat diversity, activity, and type of use to forest characteristics and landscape heterogeneity for the 135 ConFoBi plots. We expect that: (1)The species-specific use of structural elements at the local scale - and thus the effectiveness of retention measures - will be modulated by the surrounding landscape. (2)Diversity of species and functional guilds will increase with heterogeneity at both the forest stand and landscape scale.
(3) The relative abundance and diversity of forest-specialists will increase with the abundance of old forest (habitat trees) and dead wood in the surroundings.

Bat data were collected by using Bat-loggers (ultra-sonic sound recorders), and calls analysed using BatScope. In addition, species identification was refined by capturing of bats with mist nets. Forest structure and landscape patterns were assessed by remote sensing complemented with plot-scale terrestrial mapping. LiDAR-information capturing the 3D-characteristics of sub-canopy space is used to predict bat occurrence at the stand scale. By relating bat presence and diversity to structural characteristics quantitative threshold values for integrative forest management will be derived.

bats, ConFoBi, forest structure, landscape pattern

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2739 **eDNA of dead wood samples for assessing saproxylic beetles**

Keller, N.* (1); Segelbacher, G. (1)

(1) University of Freiburg, Freiburg, Germany

Abstract: In the present time of biodiversity decline, assessing species is a major issue for conservation planning. However, species assessment is often labor and cost intensive and many groups are difficult to assess at all. On the other hand genetic technologies are rapidly developing and enable us now to detect species with molecular tools, which have been previously unknown. Environmental DNA (eDNA) is now widely used to analyze water, soils and air samples in order to describe the number of species in these samples. We here focus on the characterization of insect, specifically saproxylic beetle diversity by analyzing dead wood samples, where until now only fungi and bacterial diversity has been assessed genetically. Those saproxylic beetles are considered to be important organisms in the wood decomposition process and consist of highly diverse groups with many indicator species. The taxonomic knowledge to identify beetles to species level requires typically decades of exercise. To circumvent this problem we test the feasibility of a saproxylic beetle assessment by eDNA metabarcoding. We here present preliminary results of different extraction techniques and discuss the possibility of eDNA techniques in species assessments in saproxylic taxa.

eDNA, metabarcoding, saproxylic beetles, dead wood

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2566 **Stress tolerance in high resolution - on the growth potential of invasive Ailanthus altissima in future climates**

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(1) Swiss Federal Research Institute WSL, Birmensdorf, Switzerland; (2) Swiss Federal Research Institute WSL, Cadenazzo, Switzerland

Abstract: The tree of heaven (*Ailanthus altissima* (Mill.) Swingle) successfully colonizes many temperate and Mediterranean forest ecosystems outside its native range. The thermophilous tree is expected to profit from increasing temperatures with climate change, even more due to its ability to tolerate severe drought. Thus, we hypothesize that current radial growth of *A. altissima* already outperforms co-occurring tree species in dry spells. We used point dendrometers to compare the sub-hourly radial growth responses of *A. altissima* and sweet chestnut (*Castanea sativa* Mill.) from 2013-2016 at two sites in southern Switzerland. We decoupled irreversible stem growth from reversible tree water deficit-induced swelling and shrinking to characterize and compare short-term radial growth as well as stem water movement of the two species, with a particular focus on dry and warm stress periods. Our findings can help to evaluate the growth performance of *A. altissima* in future climates and may also identify potential benefits of *A. altissima* in areas where native trees suffer from more frequent droughts.

dendrometer, radial growth, drought, invasive tree

Poster Exhibition Friday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-568 **Adaptation to climate and ungulate browsing: Are both possible?**

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(1) Swiss Federal Research Institute WSL, Forest Resources and Management, Birmensdorf, Switzerland

Abstract: Due to long-term selection processes, autochthonous tree populations are well adapted to their local environments. Consequently, provenances are differentiated in many traits. Furthermore, large herbivores have become major drivers of forest dynamics worldwide. Have traits evolved that allow both adaptation to climate change and resilience to ungulate browsing?

In an extensive genecological common garden experiment, we investigated quantitative genetic variation within and among provenances of *Abies alba, Picea abies*, and *Fagus sylvatica*. Each species was represented by approx. 90 autochthonous provenances, covering the species' ecological range in Switzerland (e.g., elevations from 330 until 2100 m a.s.l.). In 2012, approx. 4000 seedlings per species were planted in a single tree random plot design in an open-land study site. Growth and phenology were measured in 2013 and 2014. In spring 2015, the saplings were clipped with three intensities (heavy, slight and no clipping) to simulate browsing by roe and red deer. Growth reactions were assessed one and two growing seasons after treatment, and provenance differences were related to environmental variables of seed sources.

Growth traits before clipping showed higher genetic variation among provenances for *P. abies* than for *A. alba* and *F. sylvatica*, but provenances of both coniferous species from low elevations grew significantly faster than those from high elevations. Growth and clipping increased the variation in *A. alba* but microsite conditions are probably as important for determining growth and resilience after clipping as genetic differentiation among provenances. Analysing sapling traits measured two years after clipping and relating these with environmental variables of seed sources will allow identifying potential among-provenance differences with respect to climate change and herbivory and show if proper provenance selection continues to be more important for *P. abies* than for *A. alba* and *F. sylvatica*.

herbivory, population differentiation, resilience

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2043 **Population structure and density of Pinus Hartwegii in an elevation gradient**

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(1) Faculty Of Forestry Science, Linares, Mexico; (2) Universidad Juárez del Estado de Durango, Durango, Mexico

Abstract: Knowledge of the factors that influence structure and density of pines is of vital importance for forest management. One important factor is fire, which differs in its impact depending on its frequency and intensity. In this study, we compared the age structures in an elevation gradient of a Pinus hartwegii stand in Cerro El Potosí, in Northeastern of Mexico. We explored whether some age categories were under represented at some elevations due to fires. The ages of the trees were determined by means of samples of nuclei of 100 selected trees per each one of 3 elevations (3,050, 3,225 and 3,400 m above sea level). To estimate the age of young individuals, we counted branch nodes, assuming each node corresponded to one year. We compared categories of 20 years for each of the three selected elevations. For all cases individuals <20 years were the ones with the highest density. Individuals between 20 and 40 years had a high density at the central elevation and lower at the highest elevation. These results may reflect the strong fire that occurred in 1998, since the young individuals of that time were then, more susceptible to burning

age categories, plant density, altitude, fire

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3238 **Modeling natural regeneration potential in agricultural landscapes of Southeastern Brazil: an approach to decrease restoration cost and increase ecosystem services**

Molin, P. G.* (1); Santin Brancalion, P. H. (1); Chazdon, R. (2); Frosini de Barros Ferraz, S. (1)

(1) University of São Paulo, ESALQ, Piracicaba, Brazil; (2) University of Connecticut, Ecology & Evol. Biology, Storrs, United States

Abstract: Investment in forest restoration is proven financially viable for environmental and ecological benefits being provided; on the other hand, financial resources are limited. Given the high costs involved in restoration, there is a need to optimize resources to enable successful large scale actions. W used a previously developed spatially explicit model of regeneration potential to address restoration approaches, later comparing them to costs and ecosystem services provision.
We selected an 11,850 ha watershed, located in southeastern Brazil, with sugarcane (56.4%), pasture (30.0%) and forest cover (9.2%). Probabilities of regeneration were converted to restoration methods, which received specific costs regarding method, fencing, maintenance and land cost. We later conducted 3 restoration approaches to our landscape, Riparian (RIP), Random (RDM) and Cost-Reduction (CST), with the objective of reaching a 30% forest cover. In RIP we selected pixels neighboring water, in RDM, randomized pixels, and in CST, the cheapest pixels were selected. At last, we calculated benefits in ecosystem services (runoff, carbon stock and connectivity) after 15 years, in relation to the different approaches.
Results show that costs can be decreased up to 60%. On the other hand, when land costs are considered, savings are of 25%. Total environmental services were different in each approach but costs to decrease runoff by 1%, increase carbon stock by 1 ton and increase connectivity by 1% were lower when applying CST. However, this result was not consistent when land costs were considered.
The observations made show that natural regeneration is an ally for large-scale restoration projects. Correspondingly, ecosystem services and benefits from restored forests are also cheaper when CST is applied. Furthermore, when land cost is an important variable, objectives of restoration projects must be well analyzed, directing financial resources and contributing to an economical restoration strategy.

Regeneration, Atlantic Forest, Ecosystem Services

Poster Exhibition Friday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-189 **Religious aspects of sacred plants at holy city Allahabad in India**

Tomar, A.* (1)

(1) CSFER, Allahabad, India

Abstract: Tree worship is an age old practice in India as seen from the seals of Mohenjodaro and Harrapa that have impressions of sacred Peepal and willow trees.Trees are prominent in the Bagvad Gita,the Bible and the holy Kuran.A study was conducted at Allahabad during 2011-2012 to collect information about religious diversity at site about 45 km in the south-east of Allahabad city which stands at the confluence of the Ganga and Yamuna (two of India's holiest rivers).The geographical locations of the site is between latitude 25007' to 25010'N and longitude 81054' to 81058'E and its elevation is 364 feet.The study area was divided into six zones viz. Core,Buffer,North,South,East and West zones.The total number of 150 species(24 trees,19 shrubs,107 herbs)belonging to 52 families were recorded. Diversity of some religious trees also reported from each zones,for example, M.indica,traditionally been used for various religious functions and in all the sacrificial fires. F.religiosa is held sacred to Hindus and Buddhists. F.benghalensis is said to be dwelling places of the souls of our ancestors. A.marmelos leaves are offered to God Shiva.It was found that plants of religious value viz., Ficus glomerata,Ficus religiosa,Aegle marmelos Azadirachta indica,Emblica officinalis,Mangifera indica, Eugenia jambolana,Acacia catechu, Prosopis cineraria,Phyllanthus emblica Terminalia arjuna,etc were found in abundance in all the six zones as well as in nearby forest.These sacred plants are used in variety of ceremonies in various ways throughout the year by the people.Our ancestors linked various Gods and Goddesses with several plants for their conservation and named as sacred plants.India has deeprooted traditional worshiping of plants,which provide base for the grass root conservation practices.In this paper some of the plants species which have divine qualities for human health but held sacred at Allahabad region in northern India are discussed.

beliefs, conservation ,sacred, traditional

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1865 **Initiative 20x20 a Country-led platform to restore 20 million hectares of degraded land in Latin America**

Zamora-Cristales, R.* (1)

(1) World Resources Institute, Washington DC, United States

Abstract: Initiative 20x20 is a country led platform to bring under restoration 20 million hectares of degraded land in Latin America by 2020. Today, Initiative 20x20 has 27.7 million hectares of restoration pledges from 11 countries, three Brazilian states and three regional programs. The Initiative's objective is to contribute to reduce and revert land degradation in Latin America and the Caribbean. This effort supports the global land-restoration efforts of the Bonn Challenge and the UNFF New York Declaration. The 20x20 was launched by eight countries and five private investment groups at COP 20 in Lima, Peru in December 2014. The landscape restoration activities under the initiative aim to restore degraded land functionality to increase social wellbeing while improving environmental conditions and generating financial and economic benefits. Strategies may include, but are not limited to, agroforestry, tree plantations, silvopastoral systems or silvicultural management of degraded and secondary forests. The World Resources Institute hosts the Secretariat of the Initiative integrating and facilitating communication between governments, private impact investors and technical partners. WRI is also enabling funding opportunities to support the development of National Restoration Strategies in the country members and promote the developing of restoration projects in the ground by reducing investment barriers.

Landscape Restoration economics private investment

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IUFRO17-612 **Genetic diversity of Casuarina Equisetifolia**

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(1) Research Institute of Tropical Forestry, Chinese Academy of Forestry, Guangzhou, China; (2) CSIRO Australian Tree Seed Centre, Canberra, Australia; (3) Equipe Rhizogénèse, UMR DIAPC, IRD (Institut de Recherche pour le Développement), Montpellier, France

Abstract: Casuarina equisetifolia ssp. equisetifolia natural distributed in Australia, Thailand, Malaysia, Indonesia, the Philippines, Melanesia, Polynesia and Guam, etc. The EST-SSR markers were used to determine the genetic diversity and population structure among the 29 typical natural and introduced populations. Based on the 34,752 EST sequences of casuarina trees in the NCBI website until April, 2015, the 367 SSR loci can be identified from the 12,063 UniGene, only 2.93% frequency contained SSR loci. The 13 pairs of EST-SSR primers with amplified stability, clear band and higher polymorphism were obtained and used for genetic diversity analysis. The 308 alleles can be identified from the 13 SSR loci, average alleles number per loci was 23.69, range of alleles number was from 11 to 48. Range of effective alleles number, Shannon's index, observed heterozygosity and effective heterozygosity were 1.533-7.029, 0.691-2.139, 0.270-0.655 and 0.393-0.858, respectively. According Shannon's index, the order of genetic diversity level from high to low of the 5 regions was: African introduced (AF)>Asia natural (AN) >Oceania natural (OP)>Central American introduced (CI)>Asia introduced (AI)；the order of genetic diversity level of the 29 populations was given. The serious inbreeding between populations was occurred during the whole distribution. The 70.12% of total variance was from the individuals within populations. On regions level, the order of variance was: AN (81.15%) > AI (74.58%)>CI (72.29%)>AF (68.43%)>OP (61.45%). Though variation from populations accounted for only 25.42 % to 38.49% of the total variation, given the serious inbreeding that identified in the population, population selection should also attach great importance in future. Based on UPGMA dendrogram of the 29 populations proved that introduced populations of China should be from Asia natural populations, while introduced populations of Kenya, and India and Veitnam might from Oceania natural populations.

Casuarina; SSR marker; diversity; population

Poster Exhibition Friday

144 - Forest Genetic Resources of ecological hotspots: Conserving and managing for the trees of the

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2185 **Mapping marginal Hellenic fir populations by assessing dieback related to climate change with multi-temporal Landsat images**

Donta, E. (1); Dragozi, E. (1); Gitas, I. (1); Alizoti, P.* (1)

(1) Aristotle University of Thessaloniki , Thessaloniki, Greece

Abstract: Marginal/peripheral (MaP) forest tree populations are of high interest in the context of climate change as they can be subjected to drastic evolutionary changes, be threatened by decline and extinction or be source populations of high genetic and adaptive value due to their life history. Identification and mapping of ecologically and geographically/ecologically marginal populations, especially in the rear distribution edge, is of vital importance as they may be the first to experience population decline that might be compensated by tailored management strategies aiming to their conservation and sustainable use. To meet this goal, a methodology for identifying and mapping of MAPs was developed, based on GIS and remote sensing, examining the correlation of topographic and climatic parameters with marginal niches. The methodology combined NDVI images and a change detection method to map fir status (dear/alive) and was applied in Mt. Taygetos and Mt. Parnassos areas, geographically/ecologically and ecologically marginal niche respectively. Criterion for assignment of marginality was the extensive fir dieback following xerotherimic years. After map assessment and MaP identification, Multiple Correspondance Analysis was applied on the topographic and climatic parameters. The validated in the field findings indicate the efficacy of the methodology for mapping marginal populations at potential risk.

ecological marginality, GIS, remote sensing

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2331 **Evaluation of the genetic diversity of natural selected Quercus robur L. populations in the Czech Republic using nuclear microsatellites**

Cvrcková, H.* (1); Máchová, P. (1); Trcková, O. (1)

(1) Forestry and Game Management Research Institute, Jiloviste, Czech Republic

Abstract: Quercus robur L. (pedunculate oak) is ecologically and economically important broadleaved tree in the Czech Republic, with broad utilization of its wood. This species was in the past strongly reduced. There are efforts today to increase the proportion of broadleaves trees to achieve optimal forest species composition. For reintroducing of pedunculate oak, it is important to acquire more detailed knowledge about genetic parameters of natural populations. Ten important pedunculate oak populations in different stands of the Czech Republic were genotyped using 12 polymorphic nuclear microsatellite markers. The genotypic data from the adult trees imply genetic differences among the populations. In frame of all 10 analysed populations were recorded higher values of genetic diversity. The proportions of expected heterozygotes in populations ranged from 73 % to 77 %. The pairwise FST value indicated low genetic differentiation between the 10 pedunculate oak populations, because they were greater than zero, this means confirming the presence of population structuring. Not significant linear correlations were observed between genetic and geographic distances of the 10 oak populations. But most of the Moravian populations have been genetically closer. Twelve microsatellite markers were verified as highly polymorphic and suitable for genotyping pedunculate oak populations.

pedunculate oak, microsatellite markers, diversity

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2322 **Use of microsatellite markers for clonal identification in wild cherry seed orchards**

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(1) Forestry and Game Management Research Institute, Jiloviste, Czech Republic

Abstract: The Simple Sequence Repeats (SSR) method of DNA analyses were used to clonal identification in a model wild cherry (Prunus avium L.) seed orchard. Total genomic DNA was extracted by DNA Plant Mini Kit (QIAGEN) from buds taken from 91 sampled trees of seed orchard. Samples were screened using selected ten polymorphic nuclear microsatellite markers. Measuring the size of amplification products was carried out using the genetic analyser Applied Biosystems 3500. The obtained data were analysed using the statistical programs CERVUS, GenAlEx 6.501 and Micro-Checker. There were detected 65 different alleles at 10 loci in the 91 wild cherry tree individuals from seed orchard. The most polymorphic in our set of samples was locus EMPA 015A. By applying the 10 suitable markers to the 26 clones from model seed orchard we obtained genotypes. Clone affiliation declared by its owner was confirmed in 69 % of sampled trees, but on the basis of obtained genotypes, it is possible to assign 93 % of sampled tree to clones from seed orchards. The obtain results illustrate the utility of the microsatellite loci for assessing spatial patterns of genetic diversity and for individual identification.

Wild cherry, SSR markers, seed orchard

Poster Exhibition Friday

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IUFRO17-2648 **The Project Of Peat Amusement Park As Preservation Of Peat Forest Based On Local Wisdom In Central Borneo**

Maulana, F. M. N.* (1); Firmansyah, H. (1)

(1) Bogor Agricultural University, Bogor, Indonesia

Abstract: Forest fires/ peat greatly affect the environment, health, human and socio-economic aspects for the community. Environmental degradation led to changes in the physical properties of peat, peat chemical quality changes, the destruction of the hydrological cycle, soil disturbance and disruption of the decomposition process of succession, or population growth and forest vegetation. Adverse health impact of peat fires, residents reported experiencing respiratory tract infections, sore eyes and cough as a result of the smoke of burning biomass. While the social and economic aspects causing many residents around the forest who lost their livelihood from farming, livestock breeding, and hunting. In addition to protests from neighboring countries affected by the smoke into a political issue between the countries Indonesia and other countries. Most of these groups are generally peaty area was forest land. Often peat forests that are managed by humans to convert the land into Industrial Plantation Forest and plantation area of oil palm plantation reap material adverse effect on the economic, ecological, social and cultural. Mega projects based on local wisdom TWA Peat is one of the efforts to use peat forests sustainably while maintaining local knowledge of local communities. Attractions offered adapted to the natural conditions of peatland forests are Peatland Junggle outbound offers a typical outbound travel in the peat forest. Pea-zoo (Peatland zoo) tours that offer some unique fauna and Culture peat forest zone is a tourist area that offers local culture. Within one month of estimated gross income of Rp. 288 million so as to increase the income of Central Kalimantan Province.

forest fire, Local wisdom, Peatland forest

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1631 **CorCed - Suitability for cultivation of provenances of Cedar and Turkish Hazel in Germany as a result of climate change**

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(1) Bavarian Office for Forest Seeding and Planting, Teisendorf, Germany

Abstract: Genetic diversity is the basis for adaptation potential and survival of tree species under changing environmental conditions, representing the key issue of stability and productivity of forest ecosystems. To minimize the risk of climate change, we examine the suitability to cultivate drought-resistant tree species from the Mediterranean region in Germany. Therefore the Bavarian Office for Forest Seeding and Planting (ASP) has launched the project: Suitability for cultivation of Atlas cedar (Cedrus atlantica M.), Lebanon cedar (Cedrus libani A. RICH.) and Turkish hazel (Corylus colurna L.) in climate change" on behalf of the German Federal Ministry for Food and Agriculture.
The aim of the project is to test different provenances under Central European climatic conditions and assess the possibility of their cultivation. For this purpose, the ASP intend to establish a provenance trial in Bavaria and Baden-W ürttemberg. Valuable information to draft provenance recommendations can be obtained from such experimental plots.
For this purpose, we intend first to select appropriate populations of each tree species in the countries of origin. After that in the next two years we will harvest reproductive material in suitable autochthonous stands. Our aim is to start cultivation of all three tree species in the year 2017.
Therefore our institute wants to establish a professional cooperation with Universities, governmental authorities and the nursery sector in Morocco, Algeria and Turkey. The expected benefits of the cooperation are scientific knowledge transfer in the field of provenance research and the impact of climate change on forest ecosystems, applied genetic research to characterize tree populations (DNA, SNP, Isoenzyme), phenological measurements, and seed testing in the nursery. The Poster presents the "CorCed" project and the first results of seed testing and genetic characterization.

Genetic diversity, adaptation, drought-resistant

Poster Exhibition Friday

23 - Tree biodiversity at the genetic level: vital to confront environmental and livelihood challenges

KG II - HS 2121 (Uni Freiburg)

IUFRO17-733 **Pollen and seed gene flow in strawberry tree**

Ribeiro, M. M.* (1); Piotti, A. (2); Gaspar, D. (3); Spanu, I. (2); Costa, R. (3); Vendramin, G. G. (2)

(1) Instituto Politécnico de Castelo Branco, Escola Superior Agrária, Castelo Branco, Portugal; (2) Institute of Biosciences and BioResources, National Research Council, Sesto Fiorentino (Firenze), Italy; (3) Instituto Nacional de Investigação Agrária e Veterinária, Oeiras, Portugal

Abstract: Mediterranean ecosystems are vulnerable to climate change and long-term increase in drought and wildfires is expected. We investigated how pollen and seed gene flow patterns affected the *Arbutus unedo* L. (strawberry tree) populations' genetic structure in the western Iberia Peninsula, where wildfires are usually more frequent than in other Mediterranean areas. To disentangle the relative role of the different processes in highly disturbed areas is particularly difficult. Nevertheless, the relative contributions of pollen and seed dispersal to the total gene flow can be estimated, using the differentiation patterns at molecular markers with different modes of inheritance. In the present study, we investigated with chloroplast (cpSSR) and nuclear (nuSSR) microsatellites aiming at revealing how pollen and seed gene flow shaped the patterns of genetic diversity and differentiation in *A. unedo*. We have sampled fifteen *A. unedo* natural populations throughout the westernmost part of the species' distribution and used four maternally inherited cpSSRs and six biparentally inherited nuSSRs.
The mode of inheritance had a major effect on the partitioning of genetic diversity. The cpSSRs displayed higher F_{ST} than the nuSSR in the studied species, 0.28 and 0.09, respectively. The migration by pollen was 5, and by seed 2.6, with the pollen flow being twice the seed flow. The genetic diversity was lowest in the northern region with cpSSR, probably due to historical recolonization process. Conversely, the expected genetic diversity with nuclear microsatellite markers had similar values in all the populations. Nevertheless, the populations with low values of genetic diversity at cpSSRs, also displayed, in general, significant heterozygosity deficiency at nuSSRs, which might indicate some bi-parental inbreeding or genetic drift. This information will be used with genetic improvement purposes and in conservation programs design, to face the changing environmental conditions.

genetic structure; gene flow; conservation.

Poster Exhibition Friday

41 - Forest rhizosphere ecology and biogeochemistry across environmental gradients

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4135 **Young European beech plants had differently tuned root and shoot growth between dry and less-dry forest plots in summer drought of 2003 and 2011: a study on limestone outcrop in Northern Switzerland**

Chakraborty, T.* (1); Saha, S. (2); Reif, A. (1)

(1) Chair of Site Classification and Vegetation Science, University of Freiburg, Freiburg, Germany; (2) Chair of Silviculture, University of Freiburg, Freiburg, Germany

Abstract: It is known that the summer droughts of 2003 and 2011 reduced radial growth in shoots of European beeches (Fagus sylvatica L.) in Central Europe. However, the sensitivity of radial growth in roots to those drought events was less studied. Based on this curiosity, we excavated twenty young beech plants (50 to 150 cm height) from two sites in Northern Switzerland where beech plants were growing on rendzina soil of limestone bedrock at the south facing slope. We did dendroecological studies on stem and root discs. We measured the availability of light, leaf area, above and belowground biomass, the available water storage capacity of the soil (AWC), soil pH and bulk density. We found that radial growth of root was higher than shoot in dry plots, but not in less-dry plots during the events of 2003 and 2011 droughts. Roots always had higher resistance to drought than shoots. However, roots had lower recovery and resilience. The performance of roots and shoots in resistance, recovery, and resilience to drought was always superior in less-dry plots. We conclude the growth performance of roots is crucial, as roots can buffer and mitigate impacts of drought on plants' overall vitality.

Drought; root growth

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2025 **Fine root dynamics in the boreal soil fertility gradient**

Leppälammi-Kujansuu, J.* (1); Helmisaari, H.-S. (1); Laiho, R. (2); Ding, Y. (1); Minkkinen, K. (1)

(1) University of Helsinki, Helsinki, Finland; (2) Natural Resources Institute, Helsinki, Finland

Abstract: In boreal forests, roots and root-associated micro-organisms are estimated to contribute prominently to the soil C pool. In Finland, half of the land area is covered by forests. Since half of the original surface area of peatlands has been drained for forestry, a fourth of the forests are peatlands. Thus, both of these ecosystems are of importance when studying fine root-originated carbon fluxes. In this extensive project we will compare fine root production in mineral forest soils, drained peatland forests and natural peatlands, in corresponding fertility gradients. Study plots consist of mainly Picea abies and Pinus sylvestris stands (incl. understory), along their natural site fertility gradient.
For assessing fine root production, altogether 150 minirhizotron tubes were installed in the study plots for fine root turnover estimation and the same number of soil cores were taken up for fine root biomass determination. Minirhizotron images are collected four consecutive growing seasons, from May to October. Soil coring for the fine root biomass determination and for the soil nutrient analyses were both accomplished once. We aim at publishing the results in 2018.

fine root, minirhizotron, turnover, soil fertility

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1737 **Nutrient effects on plant carbon allocation - the role of mycorrhizal fungi**

Ven, A.* (1); Verlinden, M. (1); Vicca, S. (1)

(1) University of Antwerp (Department Biologie, PLECO), Wilrijk (Antwerpen), Belgium

Abstract: Forests on fertile soils have been shown to use more of their photosynthates for growing biomass than forests on infertile soils. It remains unclear though whether this increase in biomass production efficiency with increasing nutrient availability is due to lower autotrophic respiration, or to reduced allocation to mycorrhizae and exudates. Because carbon allocation to mycorrhizal fungi and exudates is next to impossible to quantify in the field, we set up a mesocosm N and P fertilization experiment to find out. In order to distinguish newly fixed carbon from carbon already present in the soil, we opted to grow the C4 plant Zea mays on a C3 soil. We determined photosynthesis, plant growth, and plant and soil respiration. We quantified the mycorrhizae and estimated root exudates. Data analyses are ongoing (and will be finalized before September 2017). Preliminary results suggest no difference in the fraction of photosynthates being respired by the plant, but a substantial difference in carbon partitioning to the mycorrhizal fungi.

mycorrhizae; carbon allocation; root exudates

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1309 **Distribution of surface-bound phosphatase on mycorrhizal structures of Hebeloma sp. on Quercus Pubescens seedlings**

Poster Exhibition Friday

41 - Forest rhizosphere ecology and biogeochemistry across environmental gradients

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1309 **Distribution of surface-bound phosphatase on mycorrhizal structures of Hebeloma sp. on Quercus Pubescens seedlings**

Straus, I. (1); Mrak, T.* (1); Hoshika, Y. (2); Carriero, G. (2); Paoletti, E. (2); Kreft, M. (3); Kraigher, H. (1)

(1) Slovenian Forestry Institute, ljubljana, Slovenia; (2) Institute for Sustainable Plant Protection, Sesto Fiorentino, Italy; (3) Biotechnical Faculty, Department of Biology, Institute of Pathophysiology, Faculty of Medicine, Ljubljana, Slovenia

Abstract: Ectomycorrhizal exploration types have become very popular functional explanation for observed patterns of fungal community structure. In this study, we examined the distribution of surface-bound phosphatase (SBP) on ectomycorrhizal mantle, hyphae and rhizomorphs of ectomycorrhizal fungi Hebeloma sp. (medium distance exploration type) and on non-mycorrhizal root tips. Hebeloma sp. was identified on oak (Quercus pubescens) seedlings (VIGORPLANT Italia srl, Italy) using morpho-anatomical and molecular analyses. Occurrence of SBP was investigated with image processed two photon confocal laser scanning microscopy (LSM 7 MP, Zeiss) using the fluorogenic substrate ELF-97 (enzyme-labelled fluorescence; Alvarez et al. 2006. Mycologia 96: 479-487) and computer analyses of images based on the programme ImageJ 1.35j. We found active SBP enzymes on ectomycorrhizal structures and also on non-mycorrhizal root tips. Significant differences ($P<0.001$) of SBP distribution were found between hyphae-ECM mantle and hyphae-non-mycorrhizal root. According to the results, we assume, that the distribution of enzymes coud be in relation to the function of ECM in the forest soil.

ectomycorrhiza, MD exploration type, enzyme

Poster Exhibition Friday

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IUFRO17-129 **Relations between gas exchanges and variation of foliar temperature of young Tachi-Branco plants (Sclerolobium paniculatum) submitted to water stress**

Brum Rossi, L. M.* (1); Ribeiro de Morais, R. (1); Victoria Higa, R. C. (2)

(1) Embrapa Amazonia Ocidental, Manaus, Brazil; (2) Embrapa Florestas, Colombo, Brazil

Abstract: A study was made about the relations between leaf temperature variation associated to water stress on the gas exchange of young tachi-branco plants (*Sclerolobium paniculatum* Vogel) plants, a fast growing native species from the Brazilian Amazon region with potential use for energy production. The study was carried out with acclimatized seedlings for four months in a greenhouse at Embrapa Amaz ônia Ocidental, Manaus, Brazil. After this period, they were submitted to three water regimes (maintained irrigated, irrigation suspended for eight and 14 days) and leaf temperature variation, obtained by means of the portable photosynthesis meter. The rate of liquid assimilation of CO_2, leaf transpiration, stomatal conductance and water use efficiency, were evaluated. There was a reduction in the liquid CO_2 assimilation rates in function of the elevation of leaf temperature and suspension of irrigation. After eight days of irrigation suspension the reductions of the liquid CO_2 assimilation rates were 62, 65, 75, 58, 50 and 64% and at 14 days were 80, 85, 85, 84, 86 and 93% compared to plants maintained irrigated at temperatures of 25, 30, 35, 40, 45 and 50 °C, respectively. The physiological behavior of gas exchanges of *Sclerolobium paniculatum* showed variations both in relation to the effect of leaf temperature and irrigation suspension.

photosynthesis, hydric stress, Amazonia

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3212 **Rooting space, soil water availability, sapflow and leaf area development regulate climate response of trees on boreal reclamation sites**

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Abstract: Surface mining for belowground resources in the boreal forest results in severe disturbance of the forest ecosystem, requiring landscape and soil reconstruction before forest cover can be reestablished. Often these landforms are constructed using overburden materials considered unsuitable for plant growth, which are capped with subsoil and top soil materials that can sustain a forest cover. These sites create unique opportunities to study the impact of rooting space on ecophysiological variables in plants. Soil capping depth influences rooting space and with that resource availability. As forests and leaf area develops, water availability could become a limiting factor. In this study we link sap flow and tree productivity over two growing seasons with soil moisture availability and rooting space. We explored climatic variables as the drivers of water availability and tree performance. White spruce (Picea glauca) and trembling aspen (Populus tremuloides) were planted on a reclaimed slope in 1999 treated with two different soil capping depths (35 and 100 cm cap) placed over saline-sodic overburden material. Trees along the slope were equipped with heat ratio method sap flow sensors over the 2014 and 2015 growing seasons. Varying tree characteristics and growth were measured, as well as soil moisture availability and weather variables. Slope position and capping depths affected the trees' wood volume and leaf area production over the two growing seasons. Sap flow over the whole growing season followed trends similar to the soil water availability for both species. Interestingly trembling aspen had greater water uptake at the top of slope, which was not observed for white spruce. Diurnal cycles of sap flow during dry-down and wetting-up periods provide a general and species specific patterns of water uptake during the growing season and highlight potential consequences of reclamation practices on tree performance.

Sap flow;boreal forest;mining;aspen;white spruce

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1425 **Soil security of a tropical montane rainforest in a changing world**

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Abstract: Tropical montane forests are mainly concentrated on higher elevations (> 1000 masl) with low mean annual temperatures of 10-18 °C and high precipitation rates. They boast thick organic soils overlying mineral layers and contain rich montane biodiversity in terms of flora and fauna. Currently, the increasing population and the improvement of gross income of locals have led to expansion of agricultural lands for food and the development of tourism industry in the highland forests. The changing climate of extreme weather patterns has also caused land erosion due to rainy season and the drying of water catchment areas due to drought. Poor management of highland rainforests has caused flash floods, soil erosion and disasters that have affected the livelihood of locals. Good management practices and innovative strategies are needed to be implemented in order to protect the declining rainforest ecosystem from extinction. Preventive measures include creating buffer zones, terracing, preventing encroachments, monitoring systems, geotextile structures, educating the public and other approaches. The aim of this study is to analyse and provide strategies to conserve tropical montane forests for soil security and sustainability, taken into consideration current economic activities and preventive measures proposed.

tropical forest, threats, conservation, climate

Poster Exhibition Monday

65 - Multifunctional tropical forest landscapes: finding solutions in science and practice

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3507 **Church forests and home gardens enhance multi-functional role of Ethiopian highland landscapes when augmented with exclosures**

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Abstract: Much of the Ethiopian highlands are deforested. Church forests and homestead agroforestry are the major surviving vegetation formation in the landscape. Church forests are located in regular spatial arrangement, always surrounded by villages and degraded farm-grazing land matrix. Home gardens are found in irregular arrangement surrounding homes. The high diversity of woody plant species in these vegetation formation suggests their role in the livelihoods of the rural poor. We studied diversity and use pattern of woody plants before and eight years after the establishment of voluntary carbon offset mechanism in northwest Ethiopia. The carbon offset was planned through the establishment of tree plantation and exclosure on former degraded communal grazing land. At the beginning, diversity statistics was decreasing from homestead to church and to the exclosure. After eight years, diversity and annual benefit increased in the exclosure, but remained constant in the church forests and home gardens. Diversity of exclosure was determined by natural regeneration processes. Diversity of home gardens was determined by household head need of forest products, including high value market trees. Diversity of church forests was determined by both natural regeneration processes, and need for tangible and non-tangible forests products of the surrounding community and the clergy.

church forest, homestead, exclosure, carbon offset

Poster Exhibition Monday

78 - Forest Operation and Ergonomics: Challenge and Solutions.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3498 **Automated Time Study of cable yarding using GPS data**

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Abstract: Time study is an important and most common research tool to evaluate and improve logging operations. Collecting data of timeTime study is an important and most common research tool to evaluate and improve logging operations. Collecting data of time study is carried out generally to observe logging operations directly or to take a video of operation scenes and then analyze videos. However, this method is time consuming and requires many personnel. Furthermore, observers are put at risk of accidents at the logging site. Cable yarding operation is very difficult to obtain sufficient sample data at a loading point, which moves every cycle with bad conditions of the ground. In order to improve an automated time study of cable yarding, cycle times and time elements are differentiated by analyzing motions of machines or persons. X, y, and z coordinate data of GPS can be applied to discriminate and analyze cable logging operations. This method is very convenience, economical and safe for researchers.
This paper reports an automated system using analysis of GPS data to estimate cycle times and time elements for cable yarding operations.

Cable yarding, GPS, Automated time study

Poster Exhibition Monday

145 - The Role of Forest History & Cultural Heritage in Re-constructing Nature - a landscape-level

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3472 **Sustainable production and nutrient management in pine and birch stands in lowlands**

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Abstract: Scots pine is a commercially important conifer tree in lowlands in the Czech Republic. The sites suitable for growing pine are usually nutrient-poor ones on sandy soils; there is a risk of nutrients depletion when removing parts of woody biomass from forest stands. Silver birch accompanies the pine frequently on moist soils. These days, pine-dominated stands are managed using a clear-cut forest system where whole boles and important part of crown biomass are removed frequently from the site. To renew the pine, forestry practitioners rely on natural regeneration from stands nearby the clear-cuts. Also reliable information on production potential of birch is still lacking in the Czech Republic. The project aims to optimize nutrient cycling in both pine and birch stands. The proposals are to be based on biomass stock (both above- and below-ground parts) and nutrient pools (forest floor and soil) in particular ecosystem components. The proposals are to minimize impact of harvesting on forest environment in terms of sustainable forest management. The first results showed annual litter-fall amounting 4 Mg.ha-1 in pine stands. No excessive accumulation of forest floor was found. Birch stands accumulated 2 - 5 Mg.ha-1 in litter-fall regardless of their age. Greater decomposition rate under birch did not allowed us to separate dry mass of F and H horizons. These two ones accumulated 10 - 20 Mg.ha-1. The only water-logged birch site showed an excessive accumulation of 100 Mg.ha-1. The information on particular nutrient pools of forest biomass components is to allow us to propose amounts of biomass to be left on site after logging.

biomass; nutrients, Scots pine, birch

Poster Exhibition Monday

169 - New comminution technologies and logistics to improve the quality of forest energy feedstock

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1287 **Review of efficiencies in comminuting of forest fuels**

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Abstract: The demand for biomasses for refinery purposes is globally increasing. Refining industries require that the biomass is down-sized to specific qualities before entering the process. To ensure delivery of solid fuel fractions at low cost and high quality, knowledge about factors influencing the comminution efficiency is fundamental when engineering operational systems. There are many studies made on specific systems and conditions, and thus there is a need of generalization of results to be used for systems analyses on e.g. international scales. Further, operational data available from equipment manufacturers are based on idealized conditions, while scientific studies consider ordinary working conditions. The study objectives were therefore to combine data from literature and manufacturers on comminution performances (e.g. energy demand, productivity, fuel quality) for various comminution systems, in order to identify deficiencies and limitations as areas for further Research and Development. Our study shows that productivity and energy efficiency of comminution systems are influenced by a multitude of factors such as e.g. produced fuels particle sizes, comminution method and the feeding rate. Based on these findings, our study point out specific issues which need to be addressed in future R&D of comminution equipment and systems.

comminution efficiency, literature review,

Poster Exhibition Monday

176 - Agroforestry - the future of land use management?

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1692 **Soil and plant hydrology of agroforestry systems: Competition for water or positive tree-crops interactions?**

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Abstract: During dry summer periods crops may suffer from severe water stress. The question arises whether the alternation of crop and tree strips enhances and sustains soil water resources for crops during drought events. Trees reduce wind exposure, decreasing the potential evapotranspiration of crops; additionally hydraulic lift from the deep roots of trees to the top soil might provide additional water for shallow-rooted crops. To understand the above and belowground water relations of agroforestry systems, we measured soil moisture and soil water potential as a function of distance to the trees at varying depth. The impact and range of the hydraulic lift into the arable land was determined with a trace experiment of heavy water. The results show that trees shade the soil surface, lowering the air temperature and increasing the soil moisture in the tree strips. During summer drought periods, the soil water potential close to the trees was less negative (wetter soil) than far from the tress (drier soil), showing the positive effect of trees in reducing evapotranspiration of arable land. Stable isotope signatures of soil and xylem water allow to show the occurrence of hydraulic redistribution and its agro-ecological impact on crop water resources during drought events.

Root water uptake, hydraulic lift, heavy water

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2875 **Biodiversity, Carbon and Chocolate: Towards an Environmentally Friendly Cocoa Production System in Ghana**

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Abstract: Rising demand for cocoa has facilitated the development of a sun-grown (zero shade) cocoa producing system which is replacing the common practice shade-grown cocoa. The zero shade system mostly involves clearing of forest land for cocoa cultivation. Although cocoa planted in zero shade system grows faster and ensures faster return on investments, it has been described as unsustainable due to potential scarcity of land for expansion and most importantly, the negative impacts it has on the environment like deforestation and land degradation. To reverse this fast growing trend, it is imperative to study the traditional cocoa shade system with an aim of increasing the viability and attractiveness with respect to both financial and environmental considerations. Using a social survey and biophysical data, this study uses a combination of social survey data from cocoa farmers and biophysical data from 36 cocoa farms (2ha or more in size) and 37 communities in the Western region, a dominant cocoa producing area in Ghana, to determine the trade-offs between cocoa production and other ecosystem services. First, measurements were made to characterize the association between cocoa producing systems and deforestation. Then, we analyzed the feasibility of including carbon management objectives in cocoa farming as an alternative income generating avenue in cocoa farming based on smallholder cocoa farmer perspectives.

Ghana Cocoa Deforestation Ecosystem Smallholder

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1363 **Above-ground carbon sequestration potential and nutrient distribution of wild cherry in an agroforestry system**

Morhart, C.* (1); Sheppard, J. (1); Schuler, J. (1); Spiecker, H. (1)

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Abstract: In our study we present detailed information concerning the biomass of wild cherry (Prunus avium L.) grown within an agroforestry system. In 2012 and 2013 we sampled 39 wild cherry trees in order to estimate the leafless above ground woody biomass. In order to facilitate a highly accurate estimation of the carbon sequestration potential and nutrient distribution within the sampled trees, biomass held within both stem and branch portions and between wood and bark compartments were investigated. The stems and branches of all sampled trees were separated into 1 cm diameter classes. Sub-samples were used for a separate analyses of wood and bark fractions. We developed models in order to describe the carbon sequestration of such trees coupled with a detailed biomass estimation for all tree compartments.
We were able to show that larger trees display a higher proportion of whole tree biomass consisting of branch biomass. However, due to larger diameters of the stem and the branches coupled with a greater percentage of wood tissues, the proportion of total bark biomass within the whole tree decreased with increasing tree size. Based on the model calculation we can show, that a single wild cherry tree, at a reasonably juvenile age of 20 years, can store 85kg of carbon above ground. Since this amount will increase as the tree matures, it can be recommended to include trees like wild cherry within AFS as an option for carbon sequestration.

Prunus avium L., Biomass, Bark, Allometry

Poster Exhibition Monday

176 - Agroforestry - the future of land use management?

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2961 **SidaTim: Novel Pathways of Biomass Production: Assessing the Potential of Sida hermaphrodita and Valuable Timber Trees**

Nahm, M.* (1); Augusti, A. (2); Bury, M. (3); Facciotto, G. (4); Graves, A. (5); Lauteri, M. (2); Martens, R. (6); Morhart, C. (1); Paris, P. (2)

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Abstract: We present our first results for the SIDATIM research project. This EU project is designed to assess the potential of a new agroforestry system consisting of timber trees and a promising new energy crop called Sida hermaphrodita.
The first part of SIDATIM is devoted to assessing the growth and use of Sida hermaphrodita. Sida is not only suitable for heat and energy production, but can also be used for the production of various materials. In Poland Sida has displayed impressive growth, generating dry biomass yields of more than 20 tons per hectare. Yet, there is little data on Sida growth in other European countries. Here, we present new results on the growth of two different Sida provenances, the competitive potential of their seeds when sown together with seed mixtures of native plants, and their adaptation to drought and shade.
In the second research pillar of SIDATIM, the research focus lies on the production of valuable timber trees in an agricultural setting - in particular, at the edges of fields or in existing hedgerows. Finally, we investigate in a synthetic approach how these two land utilization concepts can be combined in a modern agroforestry system.

Agroforestry, Virginia mallow, valuable timber

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2517 **Agricultural system of the Shipibo Konibo Indians in Amazonia**

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(1) Escola Superior de Agricultura "Luiz de Queiroz" - ESALQ/USP, Piracicaba - SP, Brazil

Abstract: Amazonia covers 61% of the Peruvian territory and is home to fifty indigenous peoples. These populations use natural resources by hunting, fishing, collecting fruits, agriculture, etc. Indigenous agricultural practices rely on ecological knowledge transmitted between generations as the basis for food production. Thus, the agricultural systems adopted reflect cultural factors and their perception of nature. This work aimed to verify the traditional agricultural systems of the Shipibo Konibo ethnic group (located in the Ucayali river basin) to understand their relations and to propose punctual methods of action in the future. Dialogues were held with Indians and field visits done for direct verification of agricultural systems. Slash and burn (itinerant agriculture) and of lowland agriculture (cultivation of river floodplains) are the most common system used. The field chosen by the indigenous varies according to the objective - size, fertility, altitude and distance of the village. The cleared areas are cultivated with rice, corn, cassava, etc. becoming a banana field after one year. This production is for sale in the city of Pucalpa due to its proximity. The induced agricultural system increased deforestation, hindered hunting and reduced area availability. It was observed that the resting period adopted (5 years) is extremely short which will lead to fertility problems. It is necessary to improve the techniques of traditional agriculture in order to preserve and reinforce the indigenous culture. The continuity of this form of land use can lead to serious ecological, economic and social problems.

slash and burn swidden shifting cultivation Peru

KG II - HS 2121 (Uni Freiburg)

IUFRO17-794 **Investigating sun induced damages on the boles of wild cherry grown within a temperate agroforestry system**

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Abstract: Growing widely spaced trees within an agroforestry system may result in sun damage to cambial tissues on sun-exposed bole faces. Damage on the south western bole face was observed on a number of wild cherry within an AFS grown for the production of valuable timber. The damage was determined to have taken place during the period of dormancy 2009. It has been suggested that there are two periods of risk of damage caused by direct insolation on exposed tree boles, the summer, when cambial temperatures become too high, or during winter, when the frozen dormant cambium tissue thaws and then rapidly re-freezes, a phenomenon commonly referred to as sunscald or southwest disease.
To retrospectively investigate influencing factors contributing to such damage, bark surface temperature data were collected over a two year period and analysed. Critical areas for elevated bark surface temperatures were found to be below 5.5m on the SW bole face. Bark surface temperatures reached a maximum of nearly 50 °C during summer and experienced a maximum range of 38 °C within a single 24 hour period in spring. The concurrent difference between the SW and NE bole faces were found to reach a maximum of approximately 15 °C.
A specially formulated white paint was applied to two trees, thus, testing an active method to reduce the risk of sun damage. Differences between painted and unpainted tree boles are more pronounced during peak daytime temperatures in early spring (max. 9 °C) where sunscald damages are most relevant.
Two models were constructed to predict maximum and minimum daily bark surface temperature using maximum, minimum and mean daily air temperature, daily sum of sunshine hours, cloud cover, wind speed, relative humidity, maximum solar elevation and height on the tree bole as predictor variables. The models were applied to identify maximum and minimum bark surface temperatures during the identified period of sun damage.

sunscald, south-west disease, bark, Prunus avium

Poster Exhibition Monday

176 - Agroforestry - the future of land use management?

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3356 **Developing a smallholder whitewood (Endospermum medullosum) plantation industry in Vanuatu**

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Abstract: Vanuatu, a least developed nation under the UN, is reliant upon wood imports, despite having excellent potential for timber plantations. Key barriers to plantation development are cyclones, infrastructure and the need for early returns for smallholders. This paper describes research on silviculture, product development and financial outcomes from Endospermum medullosum (whitewood) plantations. We utilised data on; growth of plantings established at various stockings, products from plantation thinnings at age 6 and 17, and costs of product processing, to model financial outcomes for smallholders. Product value was estimated based on costs of production and appropriate margins and then compared to radiata pine products already in the market. Financial modelling for the whole rotation was undertaken under spacing and thinning scenarios appropriate for landholders in different situations, including access to market. Where a market for thinnings is not available a direct silvicultural regime with low planting density and no thinnings had a high NPV due to an earlier final harvest. Application of the different regimes to landholder and market circumstances is discussed.

plantation wood products, livelihoods,

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1302 **Livelihood and biodiversity conservation value of traditionally managed agroforests of Meghalaya, India**

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Abstract: The tribal farmers of Meghalaya enrich the sub-tropical moist evergreen forests with betel nut bay leaf, jack fruit, and wild pepper, while retaining most native plants. Located on steep slopes these agroforests, evolved over hundreds of years eventually create a unique agroforestry system. Despite immense socio-economic and ecological value of these agroforests, no study is available on their plant diversity and management system. We investigated plant species composition of these agroforests and recorded a total of 160 flowering plant species, which included 83 trees species, 22 shrub species, 41 herb species and 14 climber species. Using socio-economic research tools we found that these agroforests are developed over a period of time by selective felling of less useful tree species and planting of economically more important trees in the forest gaps created for the purpose. A natural forest is thus transformed into an agroforest without ever clearing the land. These agroforests are mainstay of livelihood and provide cash income, medicine, timber, fuelwood and other products for household consumption as well as for sale. We conclude that this traditional agroforestry system serves as home for many economically important plant species, contributes towards in situ conservation of biodiversity and provides livelihood to the local forest dependent communities.

Livelihood, biodiversity, tribal communities

KG II - HS 2121 (Uni Freiburg)

IUFRO17-335 **Expanding Sumach (Rhus coriaria L.) in silvo-pastoral systems for empowering local people?**

ghanbari, S.* (1)

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Abstract: By simultaneously increasing cash income to rural communities and increasing value of forest and tree resources, commercialization of NWFPs is arguably a means to both forest conservation and livelihood improvement. Forests provide non-wood forest products (NWFPs) of high commercial value, such as sumach (Rhus coriaria L.). With the increasing awareness of their economic potential and growing concerns for the sustainability of the resources, local people have been encouraged to expanding of sumach woodlands. We compared the financial returns for two crop production options (wheat and lentil) and forest use, in a dry forest area known for its sumach production in Hurand forests, Iran. Hurand is located in Northwest of Iran and average annual precipitation is 290 mm. Data was collected through a systematic questionnaire survey of 92 households, randomly selected from three villages. Results showed that net revenue was highest for sumach and lowest for wheat agricultural use. The net present value of revenues from sumach was estimated to be US$ 1851 per hectare, which proved to be significantly higher than the returns from alternative land uses. Recently, forest income has increased to 55% of the average household income. Our results showed that forest land use that includes commercial NWFPs is financially competitive to some commercial crop options and offers returns of better reliability. This study showed that the average value added derived from processing was three times of raw fruits. Afforestation and inverse conversion has occurred from croplands into woodlands due to higher revenue of sumach especially in high slope lands. Woodlands would be an important factor that resulted in less soil erosion. It can be concluded that conversion of croplands into woodlands would bring sustainable benefits, particularly to the local communities through harvest and processing of sumach.

sumach, silvo-pastoral, economic potential.

Poster Exhibition Monday

31 - Quality Assessments along the wood supply chain for optimal use of the forest resource

KG II - HS 2121 (Uni Freiburg)

IUFRO17-488 **A study of the morphological properties of various wood species**

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Abstract: Distinguishing features of tree trunks and a round timber, such as the size and quality are formed during the growth of tree, as a living organism. This is accompanied by structural and morphological changes in a tree, which can be expressed with the bionics laws and laws of the dimensionless ratios.
Analysis of the structural and morphological characteristics and their synthesis with the internal structure of a tree suggests a spiral screw knot distribution in a tree trunk.
However, there are other features such as biological characteristics of growing tree trunk, growth conditions, and strong development of the branches toward the maximum luminous flux. These predetermine some uneven distribution of knots on a log circle, the so-called concentration knots in the logs. While knots are the most common defects that affect the timber grade.
This work is devoted to the study of this phenomenon and aspects of its use in sawing technology. In this case, considered a biological phenomenon, namely, the unequal distribution of knots on a log circle should be used to improve the efficiency of sawing technology. First of all here is the part of the production chain: the trunk - saw log - lumber - sawn blanks.

morphological properties, wood, quality, knots

Poster Exhibition Monday

101 - 125 Years of Forest Inventories - Past, Present and Future

KG II - HS 2121 (Uni Freiburg)

IUFRO17-283 **State (national) forest inventory in Russia: sampling design, first results, problems and perspectives.**

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Abstract: State (national) forest inventory (SFI) was for a first time introduced by new Forest Code of 2006 and first sample plots were established at 2008. Random distribution of sample plots with preliminary stratification of covered by forest lands was used in inventory design. Basic unit for all statistical calculations was 34 forest regions of Russia, separately for each of them was established needed precision of forest parameters estimations. Stratification was done using old inventory materials refreshed by remote sensing data. In stratification scheme was used such tree stands parameters as age class, yield class, group of species, land categories. Total number of strata distinguished was 49, total number of sample plots to be established in hole country was determined as much as 84700. Sample plot scheme consist of three circles with diameters of 12.62, 5.64 and 2.82 meters for trees of different diameters at breast height measurements, two circles of diameter 1.78 meters for undergrowth and regeneration estimations and one belt of 10 per 1 meter for ground vegetation description. Total number of estimated on sample plot parameters as much as 117. Main points of SFI system criticism are as follows: non focused on quantitative forest parameters estimation, have a number of other targets; haven't yet officially approved methodology which cover all kind of needed activities; applied methodology haven't been published and discussed before field works; misleading preliminary stratification based on old forest inventory data actualized by remote sensing data; random sampling design; single sample plot instead of clusters (tracts), big number of measured parameters - one sample plot per day of work instead of cluster per day; low intensity of SFI - in 9 years covered 44% of needed area.

forest inventory, sampling design, precision

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2873 **Modelling Height-Diameter curves for prediction**

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Abstract: Individual tree heights are needed in many situations, including estimation of tree volume and biomas in forest inventories. However, height measurements are tedious compared to tree diameter measurements, and therefore height-diameter (H-D) models are commonly used for imputation of tree height.

Still relevant and at least partially open research questions on H-D relationship are:
(1) What is the best function for the H-D relationship?
(2) How should the H-D model be formulated in a grouped data?
(3) How should tree heights be predicted if sample trees are not available for plot-specific calibration of the H-D model?

We recently conducted a trial to answer these questions using and extensive collection of 28 H-D datasets. The datasets represent a wide range of tree species, regions, and ecological zones, consisting of about 126 000 measured trees from 3717 sample plots. Specific R-functions for model fitting and prediction were developed to enable such an extensive model fitting and comparison.

The Näslund and Curtis functions provided satisfactory fit in most datasets for the plot-specific H-D relationship. We suggest a model formulation that properly models the grouped structure through plot-specific fixed predictors and random effects. If no height measurements for plot-specific calibration of the model are not available, the formulation of the fixed part of the mixed-effect model is extremely important. The different interpretations of marginal (population-averaged) predictions and conditional (plot-specific) predictions are emphasized. The conditional predictions can be produced only using mixed-effect model whereas marginal predictions can be computed either by using a fixed-effect model or a mixed-effect model.

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Height, imputation, mixed-effects, nonlinear

KG II - HS 2121 (Uni Freiburg)

IUFRO17-940 **Application of image-based point clouds for forest inventory and management: Study in a mixed conifer broadleaved forest in Northern Japan.**

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Abstract: Recently, there has been an increasing interest in image-based point clouds generated from high resolution aerial images acquired using unmanned aerial vehicles (UAVs) as they are considered to be a highly competitive alternative to airborne light detection and ranging (LiDAR) point clouds. However, the potential of UAVs in forest inventory has not been extensively researched and their application in structurally heterogeneous forests is not yet well established. Therefore, present study aims to evaluate the potential of UAV data to estimate forest inventory attributes using both area based approach (ABA) and individual tree crown approach (ITC). Three-dimensional (3D) variables that were derived from the image-based point cloud (generated using high resolution UAV images) were used to model common forest inventory attributes. Then, wall-to-wall maps were created for the study site, with predictions capable of being aggregated in user-defined scale (for a stand or block). Forest inventory attributes could be estimated with root mean square errors generally less than 20% of mean values indicating that image-based point clouds performed effectively in heterogeneous forest areas. UAV images may become a key data source for forest inventory as they provide accurate data, including stand delineation and visual interpretation (species, health status, maturity etc.).

Structure from motion, biophysical properties

Poster Exhibition Monday

101 - 125 Years of Forest Inventories - Past, Present and Future

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1870 **The challenge of monitoring strict forest reserves: An introduction to the monitoring method in Baden-Wuerttemberg**

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Abstract: Terrestrial forest inventory is a well-established tool to characterize forest structures in unmanaged forest reserves so as to assess their development after management cessation. Yet, all long-term monitoring programmes face the challenge of maintaining data consistency and comparability over long time periods while being flexible enough integrate new techniques and adapt to changing research questions.
In the federal state Baden-Wuerttemberg, Germany, 150 unmanaged forest reserves have been designated (as of 31.12.2016) in 83 thereof a monitoring program for forest structures is established. Starting in the 1970 the method has been substantially revised in 1993. Since then it has been gradually modified with regard to parameters, mapping and evaluation techniques. We show the main methods, problems and solutions in this context.
At circular, permanently marked sampling plots of 0.1ha, regularly distributed across the reserve area, a variety of parameters, describing forest stand and single-tree characteristics are collected. Starting with classical forestry-related tree and stand characteristics, parameters have been stepwise augmented with biodiversity-related aspects such as habitat structures, holes, or fruiting bodies of fungi. Since 2014, single-tree identification allows calculating growth and mortality. A digital workflow for data collection has been implemented which allows automatized quality checks. In addition, an automatized evaluation programme has been developed that allows standard-calculations and to assemble raw data in a user-friendly format for use in any statistical programme.
In the future, forest structure monitoring will be complemented with area-wide information obtained from automated analyses of stereo aerial photographs. Additional monitoring of fauna and ground vegetation broaden the scope towards biodiversity-related questions.

inventory, forest reserves, forest structures

Poster Exhibition Monday

102 - Bringing carbon to small-scale forest owners - role of buy-in mechanisms for bridging scales and

KG II - HS 2121 (Uni Freiburg)

IUFRO17-297 **Carbon balance calculation system: a step towards sustainability in rural properties**

Alves, E. B. B. M.* (1); Silva, L. B. (1); Jacovine, L. A. G. (1); Torres, C. M. M. E. (1); Morais Junior, V. T. M. D. (1)

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Abstract: The Brazilian agriculture is one of the main greenhouse gas emissions (GHG) source. In this way are necessary requires immediate actions to mitigate this emission and minimize their consequences in the climate change. However, many farmers are unaware of the relationship of their properties with increasing GHG emissions and the potential of forest's areas to store carbon. However, to know the farm's carbon balance involves a complex process. For this reason, we aimed was to develop a system that will ensure estimates fast, consistent and accessible to small-scale forest owners. Emissions calculation system methodology are based on the guidelines of the Intergovernmental Panel on Climate Change (IPCC) and the Ministério da Ciência, Tecnologia, Inovações e Comunicações (MCTI) of Brazil and the carbon sink data was based on scientific studies conducted in Brazil. The system was developed by the Diretoria de Tecnologia da Informa ção of Universidade Federal de Viçosa, Brazil. The system allows getting a sustainability diagnosis in farms based on the carbon balance, which corresponds at the GHG emissions and CO_2 sequestration. This may contribute to the decision making under expansion and formulation of public and private policies that assist GHG emissions mitigation. The system also helps the farmers to understand their farms situation, by showing which are the most important GHG emissions sources. Thus, it encourages the farmers with negative balance to adopt practices with less emission or to increase their carbon stock and the farmers with positive balance to keep and to increase their environmentally sustainable production. This can collaborate to achieve the certificates and environmental credits, valuing their production. We conclude that the lack of knowledge of farm carbon balance can be an obstacle to the implementation of projects aiming at the inclusion of farmers in the carbon market. Thus, this tool will be available free and could help in this process.

Calculation system; carbon market; store carbon

Poster Exhibition Monday

1 - Advances in the use of lidar data for forest carbon accounting

KG II - HS 2121 (Uni Freiburg)

IUFRO17-498 **Using LiDAR data in a double sampling system to improve carbon sequestration yield tables for New Zealand's planted forests.**

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Abstract: New Zealand's planted forests are scattered over its total land area of 27 million hectares and a North to South distance of 1600 km. They make up a small proportion of the total land area (about 7%) but play a major role in sequestering carbon and offsetting national emissions. Due to the highly scattered and fragmented spatial distribution of these forests, ground-based inventories require a significant amount of time and are costly. LiDAR data obtained using an incomplete transect approach have been used to supplement data from ground-based permanent sample plots (PSPs) providing improved estimates of carbon stocks. Although LiDAR data can assist in the estimation of carbon stocks, on its own it provides only limited information for predicting carbon sequestration by age (carbon yield tables). However, if forest age is known for each LiDAR location, LiDAR data can be used for predicting carbon yield. We tested this approach using New Zealand's pre-1990 planted forest data. A growth model was used to predict annual carbon stocks for each PSP based on tree measurements and silvicultural history. LiDAR data were collected using longitudinal plot-transects straddling each PSP and forest age obtained from forest company stand record systems for each LiDAR plot. Regression models were developed for predicting annual carbon stocks from LiDAR metrics and age. These were used to adjust the PSP derived carbon yield tables providing a moderate improvement in precision. Our approach allowed us to efficiently use information from a one-off LiDAR acquisition to improve carbon yield tables which are used for predicting and modelling carbon sequestration in New Zealand's plantation forests.

NFI, LiDAR, double sampling, carbon yield

Poster Exhibition Monday

149 - Synergies and Conflicts in the Provision of Ecosystem Services by Small-scale Forest Owners

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2764 **Costs of Sustaining Ecosystem Services by the State Forest Service in Baden-Württemberg, Germany**

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Abstract: The German Forest Act stipulates that economical, ecological and recreational functions of forests have to be considered when conducting forest management practices, creating a biomass based yet multi-functional forest management. In recent years, priorities have shifted from economical to ecological and recreational demands, especially in metropolitan areas, leading to a shift in forest management. In addition, wide ranging species protection programs have been implemented. This shift in forest management on sites with ecological and recreational restrictions has not been registered by the existing accounting system. Therefore, details of forest management and related costs are unknown. For this study, data on forest management operations in 50 forest districts was collected and analyzed, covering all growth zones in Baden-Württemberg to classify restrictions and calculate additional costs for forest management. To compare authentic operations with and without restrictions, records from the accounting system were augmented with data collected by interviews.
Results show that several different strata of restrictions exist associated with varying cost levels. Restrictions for recreation, biotope protection and road safety measures in areas under species protection, create additional operational costs, while Natura 2000 areas and forest reserves result mainly in opportunity costs as well as in increased administration costs for the State Forest Service.

Ecosystem services, costs for restrictions

Poster Exhibition Monday

Forest information for bioeconomy outlooks – a joint session of the European National Forest Inventory

KG II - HS 2121 (Uni Freiburg)

IUFRO17-212 **Evolution of the information on fuels in the National Forest Inventories in the Iberian Peninsula**

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(1) Centro de Ecologia Aplicada "Prof. Baeta Neves", InBIO, CITAB, University of Trás-os-Montes and Alto Douro, Lisbon, Portugal; (2) Centro de Ecologia Aplicada "Prof. Baeta Neves", InBIO, Lisbon, Portugal; (3) Escuela Politécnica Superior, USC. Campus Universitario, Lugo, Spain; (4) INIA-CIFOR, Selvicultura y Gestión de Sistemas Forestales, Madrid, Spain

Abstract: Fire behaviour is strongly influenced by surface, ladder and crown fuels. Crown fires typically consume nearly all the fine fuels in a forest canopy, when wind and a sloping topography are take into account.
National Forest Inventory (NFI) data can be a helpful tool in fuel modelling. In fact, fuel models for forest types can be defined as a combination of overstorey species dominance and stand structure using data from forest inventories. Fuel variables, in particular the ones that measure vertical structure are extremely important to predict fire behaviour. To reduce the probability of crown fire, forest planners should consider how canopy base height, canopy bulk density, and continuity of tree canopies affect the initiation and propagation of crown fire. Yet, the relevant information on these subjects is still scarce and scattered.
Current fire behaviour models require information on the several structure variables that can retrieved from NFI. However, the inclusion of these measurements is relatively recent. In this way, this study aims to compare the developments in Spain and Portugal using the available information of the NFIs since the first inventories in the two countries. The analysis took into account the evolution of the integration of this type of information, the reasons behind these trends, and discuss future developments.

vertical structure; fuel; vegetation

Poster Exhibition Monday

21 - Dendrochemistry - a tool to asses changes in ecosystem nutrition and forest growth.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-800 **Spatial heterogeneity of nutrients within treerings - results from LA-ICP-MS measurement**

Niederberger, J.* (1); Wichser, A. (2); Kohler, M. (1); Bleiner, D. (2); Bauhus, J. (1)

(1) Forest Sciences, Freiburg, Germany; (2) EMPA, Dübendorf, Switzerland

Abstract: Many European forests have become phosphorus (P) limited in recent decades, possibly due to increased nitrogen deposition, soil acidification and improved tree growth. Dendrochemical analyses of P might enable a retrospective analysis of P nutrition of trees and provide valuable information about the effects of short-term changes (recycling efficiency) as well as of long-term environmental trends on the P availability in forest ecosystems.
We elaborated and further developed the Laser Ablation ICP-MS methodology to measure P in individual year rings. Our ongoing work has shown that the recovery of P in wood samples using the LA-ICP-MS approach is very good. However, owing to the relatively small area captured (we used laser shots producing holes of 400 µm), single shots may not adequately represent the spatial heterogeneity of P distribution within tree-rings. This spatial variation increases the noise in our data and makes the identification of signals from environmental effects more difficult.
So far we focused on spatial patterns of P within tree rings that might have been caused by temporal variation in P through different seasonal uptake or immobilization strength. However, the difference in P content between early wood and late wood was not significant. Therefore, we will test approaches to capture the spatial variation in circumferential direction within tree rings. In addition we analyze wood anatomical structures like parenchyma rays of deciduous and conifer trees. Here we want to see how these nutrient rich tissues differ from the surrounding woody biomass and if there is also a variation within this structures e.g. in radial direction.

LA-ICP-MS, tree-ring, nutrient, Phosphorous

Poster Exhibition Monday

112 - Climate change adaptation in forest management: from applied science to implementation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2820 **Defining priorities in planning for forest adaptation to climate change: a case study on Pinus nigra J.F. Arnold reforestations in Tuscany, Central Italy**

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(1) University of Florence, Florence, Italy

Abstract: Because resources and operational opportunities are usually limited, defining priorities and critical areas is very important in planning actions for increasing adaptive potential of forests to climate change. In this study we present the case of black pine (Pinus nigra J.F. Arnold) reforestations in Tuscany (Central Italy). Expected climate change could significantly modify environmental conditions in many areas, and management guidelines for these stands encourage substitution with broadleaf species which are considered more suited to the sites. To identify critical areas for pine and at the same time evaluate the potential for broadleaf species, we assessed land suitability in a climate change scenario (A2 scenario of HadCM3 model) for black pine and for the most frequent broadleaf species naturally spreading in the pine stands. Results indicate the presence of critical environmental issues for about 20% of the total area of pine forests (10,071 ha) in the present climatic situation, a proportion which rises to 50% in the considered climate change scenario. The models indicate that turkey oak and chestnut could play a useful role in the future for increasing adaptive potential of black pine forests in the context of environmental change in the Tuscan region. Maps produced in our study are useful tools for identifying priority areas for investing in adaptation measures.

DSS; multicriteria evaluation; fuzzy set

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3774 **Forest density reduction to minimize the vulnerability of Norway spruce and silver fir to extreme drought - a risk assessment**

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(1) Swiss Federal Institute for Forest Snow & Landscape Research, Birmensdorf, Switzerland; (2) University of Freiburg, Freiburg, Germany; (3) French National Institute for Agricultural Research INRA, Champenoux, France; (4) French National Institute for Agricultural Research INRA, Nancy, France; (5) Swiss Federal Institute of Technology ETH, Zürich, Switzerland; (6) Forest Research Institute Baden-Württemberg FVA, Freiburg, Germany

Abstract: Severe droughts are predicted to increase, leading to unprecedented risks for forest health and productivity. There is an urgent need to adapt forest management to the anticipated uncertain future climatic conditions to limit impacts for ecosystems and economy. The project presented herein examines the interactive effects of drought and tree population density on the resistance and resilience of tree growth, and the ecophysiological mechanisms contributing to the drought response of Picea abies and Abies alba in long-term experimental management stands in Central Europe. The project implements an interdisciplinary research approach by combining growth and yield analyses, dendrochronology, and ecophysiological mechanistic modeling, converging into an economic risk-assessment at different spatial (tree- to regional-level) and temporal (intra-annual to decadal) scales. The outcomes of this powerful framework will contribute to developing efficient management policies for adapting spruce and fir forests to increasing drought-related risks. This may be also validated in other forest ecosystems across Europe. The project involves researchers from the NFZ.forestnet, connecting six research institutions from Nancy (FR), Freiburg (DE) and Z ürich (CH) to a strong scientific network with well-established stakeholder contacts in Central Europe.

Climate change, Ecophysiology, Forest management

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2699 **Searching for evidences for shift in tree species distribution due to climate change: experiences from Slovenia**

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Abstract: Climate change may considerably alter demographic structure of tree species. Many projections based on bioclimatic scenarios show dramatic shifts in tree species distribution poleward and upwards in the next decades. However, there is a lack of empirical evidence of the actual changes of tree species composition in the recent decades when climate warming was significant. Comparison of the distribution of juvenile and mature stage of the same tree species may reveal early signals in shifting of tree species' distribution, since seedlings grow in environment that likely changed from the time when mature trees regenerated. The objective of the study is to compare distribution of regeneration (up to 150 cm tall), recruits (trees crossing the measurement threshold of 10 cm dbh) and mature trees for selected tree species in forests of Slovenia (12,000 sq km) that occupy strong gradient of elevation (10-1830 m), mean annual temperature (1.5-13.5 °C) and mean annual precipitation (780-3800 mm). The research is based on almost 103,000 plots for mature trees and recruits, and approximately 1600 plots for seedlings and saplings (regeneration). Differences between life stages in the mean values, extremes and variability of distributions of mean annual temperature, mean annual precipitation and elevation per tree species are evaluated. Main results are discussed and advantages and disadvantages of the methodological approach are exposed.

climate change,range shift,life stages,inventory

Poster Exhibition Monday

112 - Climate change adaptation in forest management: from applied science to implementation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2024 **Forest management planning at small-scale level under different climate change scenarios**

Bahýl, J. (1); Merganic, J. (1); Výbostok, J. (1); Sedmák, R.* (1); Fabrika, M. (1); Bushenkov, V. (2)

(1) Technical University in Zvolen, Zvolen, Slovakia; (2) University of Evora, Evora, Portugal

Abstract: Current forest management planning focuses on analysing more management alternatives, especially due to the increasing risk of forest disturbances caused by climate changes and also because prompt adaptation of forest management to forest owner requests is needed as a reaction to changes. The utilisation of growth simulators in the acquirement of the information necessary for the decision process has been approved. Their usage allows us to perform quick and effective evaluation of potential forest management approaches in time. Within the case study of the owner management unit in Orava region the main task was to investigative forest management planning possibilities in real conditions from the point of four types of owners with specific preferences for the management of the area. On the base of the proposal of possible management treatments the development of the area was simulated for a period of three decades under three future climate scenarios and the multicriteria optimisation of forest management was performed using the method of interaction decision maps. A number of acceptable alternatives were obtained from the optimisation procedure, which are characterised by the approach of individual owners. The results representing the stand level were consequently processed to a level of the forest owner unit (forest management plan creation) as formulation of age class distribution. At the level of forest owner unit, age class distribution should converge to normal distribution to ensure permanent production and balance of felling. This approximation can be achieved by regulating fellings at a stand level. The results indicate that it is necessary to respect individual levels of forest management planning, what supports the utilisation of alternative solutions under different climate change scenarios.

forest management plan, simulator, optimisation

Poster Exhibition Monday

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IUFRO17-1933 **The genetic diversity of species alternatives of the future**

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Abstract: An example of this case is the species Liquidambar styraciflua L. fundamental component of the mesophyllous montane forest whose surface has been reduced considerably throughout the world, with the consequent loss of its individuals and since each tree has a genetic identity with the populations of origin, its accumulated loss leaves populations with undesirable characteristics from the anthropogenic point of view; The lost characteristics will not reappear alone in the populations, so it is necessary to establish a conservation bank that guarantees the increase of genetic diversity for which populations of Mexico, Guatemala, Honduras and Nicaragua were counted as being established in Banderilla, Veracruz show -as a product of the genotype/environment interaction- significant differences between populations, families of each population and individuals of each family, which makes possible the use of this variation in genetic restoration, conservation and commercial use of the species. A provenance/progeny test of Liquidambar styraciflua, 26 years old, including 11 provenances and a total of 78 families, was evaluated; the amount of CO2 for each genetic unit was calculated using the method proposed by the Intergovernmental Panel on Climate Change, with an exploratory and Anova analysis. It was found that the existing differences were attributable to provenances, with San Esteban (with an average content of 63.74 t of C ha-1) being the best source. Given the diversity found, it is possible, through the induction of a broad and diverse genetic base, to generate breeding programs through recurrent selections for progressive gains, as well as to induce as much genetic diversity as possible through selection and to cross have options for future selections for adaptation, restoration and environmental mitigation.

Liquidambar styraciflua L, provenance/progeny test

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IUFRO17-3403 **Breeding of deep frost-tolerant eucalyptus for sustainable biomass production under climate change**

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(1) FCBA, Biotechnology and Advanced Silviculture Dept, Cestas, France

Abstract: In contrast to some instinctive expectations, frost tolerance becomes increasingly a concern in areas experiencing rapid climate changes. Eucalypts leading breeders as well as landowners are seeking for cold-tolerant germplasm to expand plantations toward colder areas as well as to secure wood and biomass production at places already subjected to severe sudden frosts. FCBA (formerly known as AFOCEL) has been breeding frost-tolerant eucalyptus for about 50 years (Potts and Potts 1986),focusing on E gunnii and E dalrympleana to bred highly cold-tolerant hybrids with growth vigour and wide adaptability. Early efforts to perform a comprehensive sampling of the whole natural area of these species with Australian partners secured the availability of original subspecies and provenances eg a significant germplasm of the threatened E gunnii ssp divaricata.
Our program includes both traditional breeding and already operating biotechnological inputs such as clonal micropropagation and molecular markers. Significant developments in genomics are ongoing with academic partners toward increased knowledge on genes involved in cold-hardiness, growth, development and wood properties of interest for industry (pulp, bioenergy and biorefinery;eg Nguyen 2016 Physiol Plant). Remarquably, the interplay between basic genomic studies with partners and FCBA's breeding activities already improved (indirectly) the selection process while molecular breeding tools are just to be implemented. Additional minor contributing species are involved to expand the adaptation range of our varietal portfolio. In vitro rootstocks are provided to commercial nurseries for cutting production from selected varieties suited to a range of pedoclimatic conditions under soft management without any weeding nor fertlilizer although often planted on very poor soil. Significantly better performing new varieties are about to be released.Sustainability and environmental impact assesments are positive.

eucalyptus, sudden frost, sustainable biomass

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2726 **Impacts of selective logging on the genetic diversity of Cryptomeria japonica natural forest, Yanase district in Kochi Prefecture Japan.**

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Abstract: *Cryptomeria japonica* is endemic to Japan and very important for Japanese forestry. This species has been widely planted in Japan because of its excellent characteristics for commercial forestry. Selective-logging of large tree has been done in several natural old forests because of high value. However, the impact of selective logging on genetic diversity of old growth forest has never been reported. In this study, we examined the impact of selective logging on the genetic diversity of *C. japonica* was examined using both of direct comparison and simulation methods. Direct comparison of logged and remained individuals showed reduction of number of private alleles, but not of heterozygosity and allelic richness estimated by eight SSR makers. In addition, the result of simulation test also showed similar level of genetic erosion in this site. Comparison of genetic diversity between the target large tree (DBH ≥ 90cm) and small tree (DBH<90cm) using 125 SNPs associated with wood property traits showed that the difference of individual allele frequency was found in several SNPs. We also discuss how to conserve and manage such natural old forests using genetic information.

sugi, SSR, SNPs, selective logging

Poster Exhibition Monday

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IUFRO17-571 **Landscape genetics and gene flow of wild olive (Olea europaea subsp. cuspidata) in fragmented natural populations of Ethiopia**

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Abstract: Understanding patterns of genetic diversity at the landscape scale will enhance conservation and management of natural populations. Using nine microsatellite markers in this study we analyzed the genetic diversity, population connectivity and spatial genetic structure of Olea europaea subspecies cuspidata, a cornerstone species for the reforestation of Ethiopian highlands. Samples from four natural populations in northwestern Ethiopia were collected. The study was conducted at the landscape level of less than 3.5 km radius as well as on fine (intensive study plot) scale of less than three hundred meter radius. Analysis of diversity and spatial structure was also done after dividing the sample in the intensive study plot into three size classes. A high and comparable level of gene diversity was obtained among different subpopulations and size classes. Allelic diversity was lower in smaller populations. Excess of homozygotes was shown to be much lower in the intensive study plot and an adjacent subpopulation. Population differentiation on average was low, but significant. Landscape genetic analysis inferred two population groups, as a distant subpopulation was shown to form a different cluster than three adjacent subpopulations. This was also shown by sharing 80% of migrants among the three adjacent populations. Significant spatial genetic structure was formed under both short and long distance range, and different size classes at short distance intervals. Stronger spatial structure was also observed in the adult size class. An indirect estimate of a gene dispersal distance of 196 m was obtained. Implications for species management and ecosystem restoration are discussed.

Olea; spatial genetic structure; gene flow

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1756 **The small RNAome from Pinus pinaster Ait during drought stress response**

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Abstract: Small non-coding RNAs (sncRNAs) represent an important regulatory layer shown to play essential roles in several biological processes including plant abiotic stress responses. In this study we aimed at the identification of sncRNAs and their target genes involved in Maritime pine drought response in different organs. Genotypes with contrasted response to drought were selected in order to identify differentially expressed sncRNAs potentially involved in different behavior during water stress response.

Twelve libraries were constructed using as template sncRNAs extracted from roots, stems and needles, and sequenced using Illumina HiSeq2500. Using miRPursuit, an open source workflow for the analysis of plants small RNAs (https://github.com/forestbiotech-lab/miRPursuit), a total of 11,367 non-redundant sequences were identified as potential Pinus pinaster small RNAs. Exhaustive analysis highlighted a group of high confidence sncRNAs showing differential expression, including 98 conserved miRNA from 33 different miRNA families, 78 novel miRNA and 424 tasi-RNAs. Potential target genes for some sncRNAs were identified showing GO term annotations related to "Response to stress" and "Response to abiotic stimulus".

In conclusion, we provide a first characterization of the small non-coding transcriptome of P. pinaster under drought stress conditions representing an important step to uncover specific regulatory networks controlling drought adaptation in pine.

drought, miRNA, P. pinaster, sncRNAs, Target genes

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2248 **Genetic and silvicultural analyses to determine the region of origin, the growth and quality features of red oak (Quercus rubra) stands in Germany**

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Abstract: The Northern Red Oak (Quercus rubra) was among first American oak species imported to Europe and is today one of the most important foreign tree species in Germany. Despite the grown importance since its introduction, many stands in Germany are of unknown origin. In order to make recommendations which stands are more suitable for the future harvest of seeding material, this project aims to examine a possible link between the origin, the growth and the stem quality of red oak stands. This project is thus divided in two parts: (1) The determination of the origin of selected red oak stands in Germany by analysing the genetic variation and (2) the assignment of ecological and phenotypic attributes to the identified provenance. Here we will focus on examining the genetic variation of our sampled stands: analyses of nuclear- and chloroplast- encoded microsatellite markers (SSRs), amplicon-sequencing of the chloroplast DNA, SNP- ("single nucleotide polymorphism") and Indel- (Insertion/Deletion) analyses. Finally, based on the obtained chloroplast DNA-sequences, we attempt to develop PCR-RFLP markers to achieve a higher throughput. So far the relationship between origin, growth and quality features of Northern Red Oak has rarely been analysed.

Quercus rubra,origin,genetic variation,SNP,InDel

Poster Exhibition Monday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-2960 **Effect of 5-azacytidine and hydroxyurea on seed germination and response of Eucalyptus globulus juvenile plants to water stress**

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Abstract: Cytosine-5 methylation (Cy5Met) is a major and dynamic DNA modification, which is established and maintained by multiple, interacting cellular machineries. Methylation levels of some genes change along plant growth and development. Several chemical compounds were found to promote demethylation or methylation of DNA, such as 5-azacytidine (5-AZA) and hydroxyurea (HU), respectively. We examined the effect of these two chemicals on germination, development and response of juvenile plants to water deficit in Eucalyptus globulus. Seeds of E. globulus were germinated onto filter paper imbibed with water (control) or with solutions of different concentrations of 5-AZA(0, 25, 50, 100, 200µM) or HU (0, 0.01, 0.1, 1, 10mM). The percentage of final germination for both 5-AZA or HU treatments was not significant reduced but the highest concentrations of HU caused a reduction on germination speed and uniformity. In young seedlings, 5-AZA and HU treatments affected the expression of genes involved in DNA methylation and demethylation pathways. Juvenile plants (165 days old) treated with 50 µM 5-AZA and 0,01mM HU and non-treated were submitted to water deficit. Both treatments affected the physiological responses of seedlings regarding transpiration, stomatal conductance and photosynthesis. Moreover, seedlings from the HU (0,01mM) treatment produced significantly ($p<0.01$) higher plants, with significantly ($p<0.01$) higher number of branches after 165 days, when compared to control. To our knowledge this is the first study in which, the impact of methylation and demethylation agents on Eucalyptus germination, juvenile development and their physiological performance was studied. This approach seems to be a promising way to change growth and development in this woody genus.

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5-azacytidine; hydroxyurea; water stress

Poster Exhibition Monday

113 - What is the potential for CO2 mitigation of forest soils?

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1547 **Consequence of clear-cutting and drought on deep soil CO2 and N2O profile concentrations and surface fluxes in Brazilian eucalypt plantations.**

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Abstract: The major factors driving greenhouse gas effluxes from forest soils (substrate supply, temperature, water content) vary with soil depth. Our study aimed to assess the consequences of drought on the temporal variability of CO2 and N2O fluxes throughout very deep soil profiles in Eucalyptus grandis plantations at the end of the rotation and the first 16 months after clear-cut, in coppice. Two treatments were compared: one with 37% of throughfall excluded by plastic sheets (TE), and one without rain exclusion (WE). Every two weeks for 19 months, soil CO2 and N2O surface fluxes were measured using the closed-chamber method and the profile concentrations were measured at 7 depths in the soil down to 15.5m from in each treatment. CO2 and N2O concentrations measured in treatment TE were on average 17.3 and 5.8% lower than in treatment WE, respectively, throughout the soil profile. Across the two treatments, CO2 concentrations increased from 4102 ±2310 ppm at 10cm deep to 14480±2854 ppm at 15.5m and N2O concentrations remained roughly constant down to 15.5m. Improving our understanding of the spatiotemporal dynamics of gas concentrations in deep soil layers is an important issue for the management of tropical planted forests in the context of climate change.

greenhouse gases throughfall exclusion coppice

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2641 **Effects of forest management practices on carbon stocks and carbon stock changes: Results from Germany's National Forest Soil Inventory**

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Abstract: To fulfill commitments under Article 3.4 of the Kyoto Protocol, the carbon (C) sequestration in soils can be used to offset greenhouse gas emissions. The amount of C stored in forest soils however, is dependent on soil properties, climate and anthropogenic activities. Effects of site quality (texture, pH, and cation exchange capacity), forest stand structure (tree species, forest stand type, forest stand age), management (liming), and input of N-depositions on C stocks and annual C sequestration rates were studied by structural equation modelling on National Forest Soil Inventory (NFSI) data. Beside the influence of tree species, parent material and texture on C stocks and C stock changes also we found evidence of increasing carbon stocks affected by high N depositions. Moreover, it could be shown that liming reduced C stocks in the organic layer while C was increased in the mineral soil. The results of the NFSI show that the data can serve as a tool for managing soil C in respect to differing site conditions.

C-Sequestration, Management, Liming, N-Deposition

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3901 **Vulnerability of carbon storage potential with regard to tree species composition**

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Abstract: Forest ecosystems and forest cover are already affected by climate change in Hungary. Several forest types are at their lower (xeric) distribution limit, where the damages are already visible. The more sensitive beech, but even sessile oak is expected to be replaced with the less sensitive, more drought tolerant Turkey oak.
The carbon stock of soils was compared in 10 stands of sessile oak and beech. Altogether, 110 soil samples were investigated and litter samples were evaluated based on Directive of 2009/28/EC.
Soil organic carbon (SOC) and litter properties of forest stands on the same homogenous loess bedrock have shown significant differences within 1-2 km distance. The SOC values decreased in the following order by tree species: sessile oak (mixed with hornbeam) > beech > Turkey oak. Different forest tending measures and species mixture changes affected soil carbon and litter as well. The least carbon content was measured in soils of Turkey oak-sessile oak mixed stands (85.4 C t/ha on average). The highest SOC (118.3 C t/ha) was found in a highly mixed stand (silver lime-beech-red oak).
The research is supported by the "Agroclimate.2" (VKSZ_12-1-2013-0034) EU-national joint funded research project.

carbon storage, beech, sessile oak, litter, adapt

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-3496 **Intensive ground vegetation growth mitigates the carbon loss from forest clearings**

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Abstract: Disturbances are major drivers of the terrestrial carbon (C) cycle, yet recovery trajectories of C after disturbance remain incompletely understood. To understand how a failed or a delayed regeneration of forest clearings affected the C balance of a temperate mountain forest in Central Europe, we assessed the soil CO2 efflux, fine root biomass, ground vegetation biomass, tree increment as well as litter input in (i) an undisturbed section of a ~ 110 years old mature forest stand, (ii) a section of the stand which was clear-cut six years ago (no tree regeneration), and (iii) a further stand-section which was clear-cut three years ago (no tree regeneration). Total soil CO2 efflux was similar at all sections (ranging between 8.5 and 8.9 t C ha-1 yr-1). The mature forest served as overall C sink (2.1 t C ha-1 yr-1) whereas both clearings were C sources to the atmosphere. The source strength three years post clear-cut (~ -5.5 t C ha-1 yr-1) was almost twice as high as six years post clear-cut (~ -2.9 t C ha-1 yr-1), with the high productivity of the dense ground vegetation layer significantly mitigating C loss from the older clearing. We conclude that recently disturbed sites can be much smaller C sources than deduced from short-term analyses immediately after disturbance, and that the role of the ground vegetation should be more explicitly taken into account in forest C budgets.

clear cut, soil CO2 efflux, ground vegetation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1407 **Carbon sequestration to above- and below-ground pools in short-rotation hybrid aspen plantations on former crop- and grasslands in hemiboreal conditions**

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Abstract: The application of short-rotation forestry (SFR) on former arable lands brings about a drastic land-use change, which could have a significant impact on ecosystem C sequestration and allocation. Hybrid aspen (Populus tremula L. × P. tremuloides Michx.) is considered to be one of the most suitable tree species for SRF on former fertile arable lands in northern Europe, but the ability of hybrid aspen plantations to sequestrate C at the whole ecosystem level in the long term has not been evaluated yet. Based on repeated soil monitoring (at the age of 5 and 15) and destructive model tree sampling, the changes in the following C pools were estimated: above-ground biomass of trees, soil A-horizon, coarse roots and subsoil (below A-horizon up to a depth of 75 cm). Soil A-horizon SOC pool had decreased significantly on former grasslands, while no change was observed on croplands. Considerable changes had occurred in subsoil, where SOC pool increased significantly on both former land-use types. The main C sequestration in fast-growing hybrid aspen plantations took place in above-ground woody biomass. First-generation hybrid aspen plantations on former arable lands had acted as C sinks by their midterm period and therefore have a great potential for climate change mitigation despite the relatively short rotation period.

climate change; land-use change; hybrid aspen

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1397 **Quantitative and qualitative features of soil organic matter in mountain treeline ecosystems**

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Abstract: Ecosystems in treeline mountainous regions are vulnerable to climate change and are exposed to different intensity of land use and land use change. Forests, pastures and meadows with different land-use intensity in the treeline region of Central Balkan were studied to define the effects of the management intensity and different land uses on the quantitative and qualitative features of soil organic matter. Land use change caused a slight decrease in organic carbon, total nitrogen contents, soil pH and the overall soil organic carbon stock, 45 years after the afforestation activities as well as caused differences in the amount of humic and fulvic acids. Similar effect was observed after conversion of natural beech forest to spruce plantation 67 years after the change. The presence or lack of management activities in the created coniferous plantations in the treeline zone were not a prerequisite for betterment of the processes of humification and further incorporation of organic substances in the mineral soil in forest land uses. Opposite could be concluded for mountain grasslands, where relatively long term intensive grazing is hence with an increase of carbon content in superficial soil and improved soil fertility to some extents. The potential effect of land use and management intensity on carbon storage capacity in treeline ecosystems could be estimated by assessing the quantitative features of soil.

treeline, land use, management, SOC stock

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IUFRO17-2559 **Carbon sequestration in Central European forest soils - Combining soil inventory with modelling**

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Abstract: The repetition of the national forest soil inventory (NFSI) of Germany revealed that forest soils act as a considerable carbon sink between 1990 and 2006. To fulfill the commitments of the UNFCCC Germany is obliged to report greenhouse gas emissions on an annual time scale. On basis of the NFSI data soil carbon changes can be reported only by extrapolating until the NFSI will be repeated again. This approach neglects that soil carbon stock changes are dynamic. Furthermore, the NFSI is a labor-intensive enterprise and additionally to this financial aspect, due to change rates of soil parameters and their variances a repetition of the inventory makes sense only in time steps of 15 years. This situation makes it reasonable that the estimation of soil carbon changes by a soil inventory has to be supported by the application of soil carbon models. In our contribution we present results from the application of the model Yasso15 on the NFSI sites. The Yasso-model is a widely used litter and soil carbon model. We applied the model at site level by deriving the biomass input from forest inventory in combination with harvest statistics. A special emphasis was placed on the contribution of ground vegetation to biomass input using vegetation relev és and a plant-biomass-model. For model initialization the initial carbon pools were adjusted to measured carbon pools. In our contribution we will overview the results and discuss the potential of this approach for the German greenhouse gas inventory.

soil, carbon sequestration, soil inventory, Yasso

Poster Exhibition Monday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-2574 **The DiaLOG tool: a support document for deeper trust in environmental friendly logging operations**

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Abstract: A national survey carried out in France in 2012, stressed out that three main conditions are necessary to motivate a forest owner to harvest: financial output, trust in the professional service-provider and "quality" of the logging operation. Thus, the satisfaction of the forest owner, in compliance with sustainable management of the forest, has to be the objective n °1 of a logging operation.

The DiaLOG tool was designed for this purpose. Facilitating the dialogue between the forest technician and "new" forest owner, for whom a logging operation is a first, is its primary function.
Expectations and also fears of the owner are identified as "High Environmental Quality" criteria to customize the operation accordingly and reassuringly explain what is going to take place in the forest. The document also highlights preventive measures that might be relevant and how they would weight on the financial balance of the operation.

As a "support document", the DiaLOG tool was designed to be simple with photos and comprehensive vocabulary. All illustrations can be customized to fit the service and the regional context the user company is offering.

Feed-back from professional practitioners who used the tool in 3 European regions in 2016 during Simwood project will also be presented.

forest owner, environment, logging operation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2972 **Allocation of storage yards in native forest stands in the Amazon region using mathematical programming**

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Abstract: The wood production from native forests in the Amazon region is still one of the main sources of wood in Brazil. This activity, if not well planned, can cause significant negative impacts to the forest ecosystem, besides compromising the economic performance. One of the crucial phases of this process is the allocation of wood storage yards. Thus, the objective of the study was to define, using mathematical programming, the best places in the forest stand to carry out the wood storage. The study area was 638.17 hectares. For this area, 7,896 possible storage yards were generated at sites capable of meeting the demand for 1,478 exploitable trees. To deal with the planning problem, we used the p-median model. This model identifies optimal locations for opening storage yards leading to distance constraints and maximum volume to be stocked. To evaluate the model, four scenarios were tested: Patios with capacity limit with and without distance restriction and patios without capacity restriction with and without distance restriction. The results of the model were compared with the current planning of the company, which does not use any optimization method. By this comparison, it was observed that scenario 2 promoted a reduction of 18.48% in the construction of roads. This reduction, in addition to reducing costs, also reduces the environmental impacts to the forest ecosystem. On the other hand, scenario 1 reduced the need to build drag trails by 3.22 km. Scenarios 3 and 4 presented lower performance than scenarios 1 and 2. Assuming the costs to open roads and the environmental impact caused by them, for the conditions of this study scenario 2 was the one that presented the best results.

Forest Management, Optimization

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1436 **Advances in the evaluation of site quality based on remote sensing technology**

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Abstract: The estimating of Site index and site quality are fundamental theory and basic tools in forest ecosystem management and silviculture practice. It is a new approach of structure and function estimating in large area using satellite remote sensed data. At present, various remote sensing inversion model about site quality has gradually been applied to the evaluation of site quality. This paper summarized and analyzed the literatures on site quality research of remote sensing technology, evaluated their respective advantages and limitations and explored the development direction of the future. The research will help to analysis site quality spatial distribution pattern in large-scale long time series, and provide technical support for large-scale afforestation of forestry management.

vegetation index; site quality; inverse model

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-4037 **Maximizing revenue from loblolly pine (Pinus taeda) plantations in the western Gulf region of the US including risk abatement values**

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Abstract: Loblolly pine growing in southern pine plantations throughout the western Gulf region of the southern US are a significant source of forest products and revenue. Demand for this resource is projected to increase over the next 30 years. As forests in this region come under increasing pressure from parcelization, urbanization, and climate variability it is important to develop silvicultural practices and strategies to minimize the risk of catastrophic loss from these growing pressures. A recently released web-based application, Forest Thinning Scheduler, is being used to model loblolly pine plantations with lower densities and genetic gain to determine thinning and harvesting regimes that maximize internal rates of return. The novelty of this approach is in the methodology for how risk abatement is quantified due to improved management strategies and to determine its economic value for the rotation. Results and their implications for incorporating risk abatement in the financial aspects of loblolly pine plantations will be discussed.

Loblolly, DSS, Risk, Thinning

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1155 **Forest Roads Design and 3D Visualization for Steep Mountains**

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Abstract: In Japan, forestry has meaningful roles in not only the local economy but also preventing from mountain disaster. However, Japanese forestry has declined because forest road density is less than 20 m/ha where more roads have to be constructed. One of the main reasons is that slopes with over 20 degrees occupy approximately 70 % in mountainous areas. In addition, planning forest roads is relied on only intuition and experiences of skilled workers and it prevents novice workers from sharing the whole picture of forest roads, as well as planning it.

In this study, we propose road designing and visualizing system as a beginning of study for solving these problems. We input a 3D mountain shape where we want to design roads. Then we apply Dijkstra's algorithm how angle of forest roads should not exceed threshold. Using this approach to six Japanese mountain forests, we can obtain gentle roads whose average angles are less than 15 degrees. Then we visualize the road on the 3D shape by interactive tool called Siv3D.

We proposed a revolutionary method to search a gentle road using Computer Graphics technique. As our future work, we will verify this searching method and add more considerations.

3D Geometry, Forest Roads, Visualization

KG II - HS 2121 (Uni Freiburg)

IUFRO17-320 **Sustainable Forest Management Planning with Indigenous Communities in British Columbia**

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Abstract: Forest management in British Columbia (BC), Canada is currently undergoing changes to better account for Indigenous values. This paradigm shift is caused by a changing ownership structure with a move towards Aboriginal title on substantial areas of the provinces' forested lands. We collaborated with four Indigenous communities in BC to develop sustainable forest management plans (FMP) for their traditional territories. Community members were interviewed to determine the goals and values for their forests. Alongside economic goals, these included habitat conservation for important game species, water quality, berry production, and the use of sustainable harvesting methods. To represent these findings, we developed criteria and indicators for use with forest estate modeling software, such as Woodstock. The criteria and indicators we developed with the communities allow a more holistic approach when it comes to FMP. Scenarios were created to support their expressed goals and values, as well as timber production and a harvesting schedule. The scenarios provide these Indigenous communities with strategic plans to assist in risk mitigation, concerning issues such as climate change and wildfire. These scenarios can help predict the future of BC's forests and demonstrate forest management strategies that encompass the three pillars of sustainability.

First Nations, decision support, community values

Poster Exhibition Monday

61 - Decision Support Approaches in Adaptive Forest Management

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1998 **Advances in Risk-Based Decision Support for Wildland Fire Management**

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Abstract: Managing large wildland fire incidents can be an uncertain, dynamic, and time-pressured decision environment. In this presentation we will review recent and emerging innovations in risk-based decision support aimed at improving the safety and effectiveness of large fire management. The design and development of these decision support tools is premised on the usefulness of pre-fire assessment and planning in terms of dampening time pressures, reducing uncertainties, expanding options, and clarifying risk-benefit tradeoffs that unfold over different time horizons. Specifically we will highlight four key themes: (1) quantitative fire risk assessments; (2) suppression difficulty, opportunity, and safety indices; (3) pre-identification and ranking of potential control points; and (4) strategic response zoning and perimeter control optimization. We will provide examples from case studies on landscapes across the western United States and southern Spain, and describe how they can help fire managers balance factors relating to cost, responder exposure, probability of success, and consequences in order to determine efficient response strategies. To conclude we will describe prospects for interfacing these advanced tools with existing decision support systems, and identify incremental next steps for model refinement.

Uncertainty, natural hazards, assessment, modeling

KG II - HS 2121 (Uni Freiburg)

IUFRO17-605 **Modelling Consequences of Regional Scale Forest Planning for Adaptive Management Where a Number of Decision Makers Exist**

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Abstract: It is essential for regional scale forest planning to consider the uncertainties about how extent it can govern individual forest activities. Plural and independent decision makers may exist and not fully understand its policy. For achieving sustainable forest management, predicting the consequences of regional planning on individual decision makings and a future provision of forest ecosystem services is needed.

The objective of this study is to construct a model to simulate the influences of forest zoning on future multiple functions by affecting individual management activities. Bayesian Network model was used to estimate relationship between zoning and individual forestry activities in order to reduce the uncertainties. This relationship was represented as conditional probabilities and used to predict forest activities and resource allocation of the future. Then, forest functions of predicted forest allocation were evaluated by regression models created from National Forest Inventory of Japan.

As a case study, this model was applied to Ugo, a small town with abundant forested area in North-East of Japan. Results revealed that zoning could improve multiple forest functions such as wood production, biodiversity, or soil conservation by affecting individual forest activities. This kind of model can support decision makings of adaptive regional forest management.

Bayesian Network model; Forest Zoning

Poster Exhibition Monday

95 - Forestry classic´ for the future

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IUFRO17-351 **Crown thinning effects on growth of Pinus taeda stands in southern Brazil**

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Abstract: Pine plantations cover 1.6 million hectares in Brazil. Besides for pulp and paper, sawtimber is increasingly needed, even of high quality timber. In a field experiment the growth, wood quality and economic results of crown thinnings in loblolly pine stands were evaluated. Treatments included variants with selection of potential crop trees (pct) and different thinning intensities: 'without' interference, 'practice-oriented' variant (400 pct ha^{-1}, moderate release from competition), 'extreme' variant (150 pct ha^{-1}, early reduction). Pcts were pruned, plots twice replicated and randomly distributed.
At age 30 years the mean volumes of the 100 thickest trees ha^{-1} in the stands 'without', 'practice-oriented' and 'extremely' thinned variants were 2.8:4.0:5.3 m^3, respectively - an increase of 90% between extremes. The highest total volume production ha^{-1} was obtained in the stands with 'practice-oriented' thinnings, however, the values of the stands 'without' and 'extreme' thinnings did not differ statistically (1,000:1,400:1,000 m^3 ha^{-1}). Altogether, results indicate that the production of large-sized trees due to crown thinnings is a realistic management goal for loblolly pine stands in southern Brazil, being economically profitable the more intense the thinnings are. Taking current market demands into account, no constraints related to wood quality could be found, even after extreme thinnings.

Loblolly pine, silviculture, forest management.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3765 **Long-term effect of whole tree biomass harvesting on ground vegetation in Scots pine stands in Latvia**

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Abstract: Logging residues are currently being extracted to cover increasing demand for renewable energy. Supply of this resource is limited and further (currently more expensive) alternative - stump extraction - is tested or applied in numerous countries. However, before application of such management activity analysis of its long-term consequences needs to be carried out. Aim of our study was to assess the long-term impact of whole tree harvesting (WTH) on ground vegetation in hemiboreal forests.
Transects for assessment of ground vegetation were placed in Scots pine stands on nutrient poor (Vacciniosa) and relative rich (drained: Myrtillosa mel.) mineral soils, where WTH was carried out experimentally 47 years ago. For comparison transects were place in the same forest types close to the WTH sites in stands at the age close to 10, 40, 110 and 160 years.
Composition of ground vegetation was changing by the age of the stand. Based on results of analysis of similarities (ANOSIM) in Vacciniosa ground vegetation in WTH area was most similar (R=0.08) to that in un-treated site at comparable age (control). Also similarities between ground vegetation in these sates and un-treated mature (110 years) stand were comparable (R=0.39 for WTH and R=0.25 for control). The same tendency, but notably lower similarities, was observed in Myrtillosa mel., indicating limited long-term impact of this radical forest management activity on ground vegetation. This conclusion was supported by number of species and appearance of rare (protected) ground vegetation species in WTH area.

biomass removal; whole-tree harvesting

Poster Exhibition Monday

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IUFRO17-1758 **Stand structure after thinning in 1-2 m-wide boom-corridors in young dense stands - First year results**

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Abstract: Boom-corridor thinning (BCT) is proposed as a cost-effective technique for biomass thinning (BT) in young dense stands. The objective was to determine how various BCT operations affect stand structure following BT. Two series of field experiments were established; BCT1: Three sites in south of Sweden (9 and 11 m in mean/dominating tree height) with five treatments, including a control, conventional selective thinning and three BCT treatments (1m, 2m wide corridors and selective BCT); BCT2: Three regions in Sweden (north, middle, south), with two stand sites in each region with different tree heights (4/9 m, 5/10 m in mean/dominating tree height). Treatments were control, pre-commercial thinning (PCT), conventional selective thinning and BCT (high and low thinning). Following the first biomass thinning, BCT regimes and selective thinning methods resulted in similar stand structures based on the number of possible future crop trees (>80 mm in diameter at breast height). However, BCT maintained a higher diversity of tree sizes as well as more stems per hectare, including deciduous species, than the selective thinning approaches. The stands after BCT should have more vertical complexity, especially when compared to PCT. The structural heterogeneity resulting from BCT may also increase stand biodiversity and ecosystem service values.

bioeconomy, future crop trees, heterogeneity

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3254 **Agroforestry System Combining Deep-Row Applications of Biosolids, Short Rotation Wood Crops, and Reclamation of Mine Spoils**

Kays, J.* (1); Felton, G. (2)

(1) University of Maryland, Western MD Res. & Ed. Ctr, Keedysville , United States; (2) University of Maryland, Environmental Science & Technology Department, College Park, United States

Abstract: A unique agroforestry system combines short-rotation hybrid poplar production and the deep row application of biosolids to reclaim mine spoils or marginal soils, solving the problems associated with surface application of biosolids, while providing environmental benefits and a positive cash flow. The deep row technique was developed by ERCO, Inc. on a 93-acre gravel spoil in Prince George's County, Maryland and involves a one-time application of 171-295 dry tons per acre in deep rows (30" deep X 42" wide) and dug 8-feet apart. The deep row is filled with biosolids, covered with overburden, and planted with hybrid poplar cuttings. After 6-8 years the roots mineralize the nutrients, and the site is harvested and retrenched. The success of deep row with forest trees appears to be dependent upon one or a combination of two factors: the presence of a restricting clay layer that minimizes downward movement until tree roots colonize the site and utilize the mineralized nutrients; and/or, rapid root formation by hybrid poplar which provides oxygen to the biosolids, and increases mineralization and nutrient uptake. A 7-year research study using different application rates found no more nitrate leaches from the site than that of a well-managed corn field, but the technique recycles large amounts of biosolids on a small footprint. The technique is being used to reclaim coal sites in Pennsylvania, Ohio, and British Columbia. This presentation will discuss other applications and refinements.

biosolids, hybrid poplar, deep-row, nitrate

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IUFRO17-4011 **Are there different growth patterns of Bertholletia excelsa in Amazon region?**

Mattos, P.* (1); Canetti, A. (2); Curto, R. (3); Braz, E. (1); Tonini, H. (4); Tardin, A. (4)

(1) Embrapa Florestas, Colombo, Brazil; (2) UFPR, Curitiba, Brazil; (3) UFMT, Sinop, Brazil; (4) Embrapa Agrossilvipastoril, Sinop, Brazil

Abstract: Bertholletia excelsa Bonpl. presents great importance to produce Brazil nuts, and could also produce wood, but it is restricted because it is listed as threatened species. The objective of this work was to characterize growth pattern of B. excelsa in four different counties in Mato Grosso State, Brazil, far at least 200 km from each other. Increment cores were collected of 20 trees on each site. Growth modeling was adjusted for each site using growth ring series. Kruskal-Wallis analysis was carried out to compare equations. Johnson-Schumacher model presented the best statistical parameters and adjustment to real data. Inflexion point was determined at 65 cm of dbh in all sites, with trees presenting near 90 and 125 years old in sites with faster and slower growth, respectively. Biggest increments (average 0.8 cm) were observed in dbhs from 40 to 70 cm. Alta Floresta and Cotriguaçú counties, located in northern region, presented similar and statistically higher growth than Itauba and Juina indicating that trees grow faster in Open Forest, probably due to exposition to tropical monsoons, than in transition Seasonal Forest typology, with rains concentrated on summer. Results will subsidize future management actions of this natural resource in Amazon region.

dendrochronology, forest management, Brazil nut

Poster Exhibition Monday

42 - Open Session

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IUFRO17-295 **Using spatial modeling to understand the role of facilitation in forest regeneration: a case study of degraded mangroves**

Pranchai, A.* (1); Jenke, M. (2); Vogt, J. (3); Grueters, U. (3); Berger, U. (3)

(1) Department of Silviculture, Faculty of Forestry, Bangkok, Thailand; (2) Institute of International Forestry and Forest Products, Technische Universität Dresden, Tharandt, Germany; (3) Institute of Forest Growth and Forest Computer Sciences, Technische Universität Dresden, Tharandt, Germany

Abstract: The successful establishment of tree seedlings and saplings depends on multiple abiotic and biotic factors and their spatial heterogeneity. However, ecological studies often ignore these spatial dependencies. We investigated the regeneration of black mangrove (*Avicennia germinans*) in a degraded site to present one application of spatial modeling in forest restoration ecology.

Gibbs point process modeling was used to analyze the spatial dependency of seedling establishment on local environmental conditions and plant interaction in six 400 m² plots. This approach enabled us to integrate spatial trends, environmental patterns and interactions among trees, saplings and seedlings. The validity of the model and its sensitivity to the considered abiotic and biotic factors were assessed using residual, leverage and influence diagnostic tools.

Our results showed that *A. germinans* seedling density was significantly higher around conspecific tree crowns and within patches of herbaceous salt-marsh vegetation. The latter contained a higher sapling density indicating that herbs facilitated forest regeneration through environmental amelioration. Dense clustering of saplings was likely a result of facilitative outweighing competitive interactions among *A. germinans*.

This implies that herbaceous salt-marsh plants could accelerate the natural regeneration of severely degraded mangroves. Intra-specific facilitation could be utilized through cluster plantings to increase seedling survival.

Gibbs point process; mangrove restoration

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IUFRO17-1926 **Evaluating site differences on growth and wood properties of radiata pine trees in Chile**

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(1) Bosques y Sociedad, Valdivia, Chile; (2) Facultad de Ingeniería Forestal, Ibague, Colombia; (3) SCION, Fendalton, New Zealand

Abstract: Radiata pine (Pinus radiata D. Don) is the most important commercial tree species for producing pulp and solid wood products in Chile. These plantations are located across a wide range of site conditions leading to high variability in productivity and the quality of wood produced. In this research, we performed a longitudinal analysis of wood properties of 17-year-old trees from the same half-sib family growing at three contrasting sites. Using SilviScan-3 imaging analysis a detailed measurement of ring width and wood properties was made. The objectives of this research were to (i) quantify between-site differences in juvenile and mature wood, (ii) investigate the radial pattern of wood properties, (iii) characterize the strength of relationships between wood properties, and (iv) evaluate between-site differences for early- and latewood properties. Although a similar growth rate between the three sites was observed, there were significant between-site differences in some wood properties. We found that between-site differences and correlations between wood properties were more marked for mature wood than juvenile wood. Advances of further research is presented in order to identify the environmental variables that drive differences in wood properties across sites.

growth, SilviScan, wood properties

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3253 **Possibilities of using the Integrated Wood Protection in the Conservation of Wooden Artifacts**

Unger, W.* (1)

(1) University of Applied Sciences Potsdam, Potsdam, Germany

Abstract: Possibilities of using the Integrated Wood Protection in the Conservation of Wooden Artifacts

Unger, Wibke 1 and Thomas L. Woods 2

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2Wood Preservation Consultant, Granville, New York, U.S.A.

In this paper we discuss the advantages and disadvantages of various integrated wood protection materials and methods in the field of conservation and preservation of valuable wooden artifacts. Wood conservation comprises the protection of wood of historic and/or archeological significance. The profession has a well-established and important history for academies of arts and for skilled restoration professionals. Architectural conservation includes the preservation of the physical structure of objects in historical sites as well as the protection of historic buildings and monuments.

Integrated Wood Protection encompasses all measures designed to permanently prevent the damage or destruction of wood and wood-based materials by insects, fungi, marine borers, and bacteria. These measures, compatible with environmental protection, are intended to safeguard the durability of wood with respect to function and aesthetic appearance.
The measures for Integrated Wood Protection may be preventative or remedial.
Measures relating to building technology include selection of wood species resistant to biodeterioration and construction methods which protect wood from moisture accumulation and adverse weathering effects.

Poster Exhibition Monday

194 - "Protection with natural products"

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IUFRO17-1373 **Evaluation of Essential Oils and Extracts of Different Plant Parts from Zelkova serrata against Phellinus noxius**

Cheng, S.-S.* (1); Chen, Y.-H. (2); Lin, C.-Y. (2); Chang, S.-T. (2)

(1) Experimental Forest, National Taiwan University, Nantou, Taiwan; (2) National Taiwan University, Taipei, Taiwan

Abstract: Brown root rot fungus Phellinus noxius has caused severe damage to more than 120 tree species in Taiwan. Zelkova serrata Makino (Ulmaceae), one of the five most valuable broadleaf trees, is an endemic tree in Taiwan. The aims of this study were to investigate the antifungal activity of essential oils and extracts of different plant parts from Z. serrata against P. noxius. In addition, the essential oils of heartwood, sapwood, twig, and leaf from Z. serrata were collected by hydrodistillation and their chemical constituents were analyzed by gas chromatography (GC) and gas chromatography-mass spectroscopy (GC-MS). Using GC and GC-MS analyses, the major compound of essential oils from heartwood, sapwood and twig was (-)-7-hydroxycalamenene (89.19%, 88.61%, and 17.72%, respectively); the major compound of essential oil from leaf was (-)-Terpinen-4-ol (22.61%). According to the antifungal tests against P. noxius, the heartwood essential oil and ethanolic extract of Z. serrata had strong antifungal activity, with the IC50 values of 11.4 and 36.7 ug/mL. It is proposed that due to the excellent antifungal activity of heartwood essential oil and ethanolic extract from Z. serrata they would be useful materials in eco-friendly antifungal agents.

essential oil, Phellinus noxius, Zelkova serrata

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IUFRO17-1021 **Unsterile soil burial soft rot test of normal and hot water extracted woods to study the influence of wood extractives on soft rot resistance of Malaysian hardwoods**

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(1) Universiti Malaysia Sarawak, Faculty of Resource Science and Technology, Kota Samarahan, Malaysia; (2) Deceased, formerly, Oxford Forestry Institute, University of Oxford, Oxford, United Kingdom

Abstract: Replicated test wood blocks {size: 10 x 10 x 20 (long.) mm] of heartwood or sapwood of 19 Malaysian hardwoods including Scots pine as reference, with blocks either normal or having extractives removed by 48 hr hot water boiling, were subjected to a 42 weeks non-standard laboratory soft rot decay test in unsterile soil incorporating Chaetomium globosum, to gauge the relative loss of soft rot resistance of woods related to extractives depletion in this manner (conversely whether extractives govern such biological durability). Results showed for some woods, significant (P<0.05)intra-species soft rot decay rates (as %mass losses)between normal and extracted samples prevailed, either showing reduced or else increased mass losses after extractives removal. About 50% of the species studied however showed no significant variations in mass losses between normal and extracted blocks. Three categories of the effect of hot water soluble extractives on soft rot resistance of Malaysian hardwoods were thus obvious, but this also encourages one to similarly explore the effects of other forms of wood extractives (eg. methanol soluble extractives) to have a better understanding of the extent of in-situ wood protection against soft rot in different tropical species imparted by extractives.

Wood extractives, Malaysian timbers, soft rot test

Poster Exhibition Monday

67 - Managerial Economics and Accounting: Where We have Been & Where We Can Go

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3665 **Uniform management problem of forest resources and determination of bottlenecks (example of Turkey)**

TÜRKER, M. F. (1); BERKER, E.* (1)

(1) Karadeniz Technical University, Trabzon, Turkey

Abstract: Forest ecosystems, which are one of the most important elements of the natural resources on Earth due to their renewable nature, spread over about 3.9 billion hectares and cover about 30% of the earth's surface. Although forests provide several products and services for human use, humans usually utilized the forests as a wooden raw material supply. But changing and evolving environmental conditions, and the increasing demands of the society on the forests, the internationalization of forestry policies and activities, have made it compulsory to take advantage of forests in different ways. However, the increasing demand for non-wood forest products on a global scale, for green spaces and recreational needs and activities, the reduction of quality water resources, the increase in the tendency towards social activities such as hunting and wildlife demonstrated that the uniform management of forest resources will be insufficient for the economic success of the forestry sector. Studies conducted in Turkey showed that mainly wood raw material production is in the focus of the forestry sector management in our country. Although the country has rich non-wood forest products, it could be argued that this sector was not given the attention it deserves and even ignored in certain cases. However, this approach contradicts with the contemporary forestry approach and constitutes an important problem in the effective and efficient management and operation of forests. The objective of the present study was to indicate the bottlenecks due to the uniform management of the Turkish forestry sector and to propose recommendations to overcome these bottlenecks.

Uniform management, Turkish forestry, bottlenecks

Poster Exhibition Monday

109 - Promoting forest biodiversity through structural complexity? New advances in the assessment and

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1073 **Close to nature forestry (Ukraine experience)**

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(1) Ukrainian National Forestry University , Lviv, Ukraine

Abstract: Close to nature forestry is a system of organization and management in forestry that ensures continuous reproduction of forest stands and formation of their utmost similarity to the natural ones in terms of structure and genesis. Such stands at various stages of development and at different levels of vertical and horizontal links are constantly present in this way on forest areas. This approach provides the transition from continuous logging management, now dominating in Ukraine, to selective one, i.e. restoration of natural all-aged forest stands with vertically and horizontally tiered closed structure, based on natural regeneration.
Methodological basis for this consists of eight principles in Ukraine: reproduction and formation of biologically sustainable all-aged forests, similar by the natural structure and dynamics to the virgin forests; the constant presence of forest cover; preservation of biodiversity; maintaining of forests ecological functions; increasing of planting productivity; green methods for harvesting and skidding of wood; the introduction of combined environmental economics criteria for forest management evaluation; public involvement in forest management; compliance with pan-European criteria and indicators for sustainable forest management under existing certification Program.
In Ukraine forests are intensively managed and thus converted mainly into coeval and often homogenous breed stands. To implement close to nature forestry, they should be transformed in all-aged mainly mixed forest stands. This is a very complex and long process. It includes various time- and space-shifted activities in forest management associated with logging, stimulation of natural regeneration, controlling age and spatial structure of plantings etc.
Transition to close to nature forestry in Ukraine has the best perspectives in terms of environmental, economic and social components of sustainable multifunctional forest management.

multifunctional, close to nature forestry, Ukraine

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1109 **The Linkage of Scales in Remote Sensing Biodiversity Assessment in Forests.**

Frey, J.* (1)

(1) Albert-Ludwigs-Universität Freiburg, Chair of Remote Sensing and Landscape Information Systems, Freiburg, Germany

Abstract: Diversity of species in forests, however measured, is strongly influenced by forest structures. These structures vary in scale from micro habitats to general landscape structures, depending on the species of interest. Consequently remote sensing techniques in biodiversity science where adapted to single species, groups or families, but rarely integrated for a broader overview. Platforms and sensors are suitable for different scales as well, while coarse satellite or airborne images are suitable, cheap and easy to use to asses landscape structures, they fail to reveal small habitat structures. Terrestrial Laser Scanners (TLS) have the opposite viewpoint, while we can gather a detailed insight of the local small scale structures, it is nearly impossible to collect these information on landscape level due to the work intense usage.
This study aims to bridge this gap by combining satellite-, UAV-, and TLS-data for a multiscale assessment of forest structures in comparison to various taxa abundances recorded by associate research projects. Within the project (ConFoBi), data will be gathered on 135 research plots where structural parameters will be collected. These structures include micro-habitats, forest gaps, tree cover, standing dead wood, etc. See confobi.uni-freiburg.de for a broader overview.

structures, biodiversity, TLS, UAV, remote sensing

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IUFRO17-2189 **Effects of ecological restoration to promote structural variability in boreal forests**

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(1) SLU, Department of Wildlife, Fish and Environmental Studies, Umeå, Sweden; (2) Natural Resources Institute Finland (LUKE), Oulu, Finland

Abstract: Restoration of boreal forests by emulating natural disturbances is used to bring back components typical of natural forests that are reduced by silvicultural management, such as structural diversity of forest stands. In a large-scale field experiment with decadal monitoring data (2005-2015), we assessed how alternative restoration methods (fell and fell+burn) affect the structural diversity of boreal forests including deadwood and living tree diversity and volume. In ten years, restoration by fell+burn increased both the volume and diversity of deadwood, whereas fell only increased the volume of deadwood. The living tree stand structure was best diversified by fell+burn treatment, but in the most severely burned stands all trees died within 2 years after treatments, imperiling the continuity of deadwood in the future. In mixed-wood stands the burning enhanced the establishment of new generation of deciduous trees, but in pine-dominated stands hardly any deciduous establishment was seen in ten years. To conclude, restoration clearly speeds up the development of the deadwood volumes needed to host large portions of biodiversity, and burning is the most effective restoration method in terms of deadwood volume and diversity as well as in promoting deciduous undergrowth.

Fire, Deadwood enrichment, disturbance, deciduous

Poster Exhibition Monday

109 - Promoting forest biodiversity through structural complexity? New advances in the assessment and

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IUFRO17-2530 **Integrating small-scale timber harvest in the restoration of a Douglas-fir stand in the Gulf Islands in British Columbia, Canada.**

Hohendorf, Q.* (1)

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Abstract: The Galiano Conservancy Association, a local land trust, conducted a restoration project of a cut and replanted Douglas-fir (Pseudotsuga menziesii) stand in 2003. Before the treatments, intensive baseline data were collected. Treatments were manual (i.e., without fossil fuel machinery) and included re-distributing large snags. Early assessments have found positive effects on floristic diversity and stand structure heterogeneity.

I will compare the early assessments with new results of the treated area, an untreated control area, and a mature reference stand to assess the development of biodiversity and stand structure. I will be using standard forest assessment methods for all layers of the forest ecosystem. I will evaluate the integration of small-scale timber harvest in the restoration to partly offset the costs. The long-term goal is to introduce sustainable forest use that assures ecological integrity while generating income.

The research will inform small-scale restoration in the Douglas-fir biogeoclimatic zone, especially in the Gulf Islands archipelago. The ecosystems in this zone are adapted to dry and warm summers and are likely to grow in importance and extent in a warming climate. It will be increasingly important to restore forest in this zone to guarantee forest cover and habitat for many highly specialized species.

Ecological restoration, Douglas-fir

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IUFRO17-1312 **Tree microhabitat structures as indicators of biodiversity in Douglas-fir forests in the Pacific Northwest, USA**

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(1) Thünen Institute of Forest Ecosystems, Eberswalde, Germany; (2) WWF World Wide Fund for Nature, Berlin, Germany

Abstract: Tree microhabitat structures are a suitable indicator in the monitoring of biological diversity in forest ecosystems as they provide habitat for many, often rare species and require comparatively little resources for their observation in the field.

The objective of this study was to apply the concept of tree microhabitats to Douglas-fir forests in their native range in the Pacific Northwest of the USA by reviewing their importance for forest biodiversity in the literature and assessing their value as indicator in the field.

When comparing the abundance of microhabitats in Douglas-fir dominated stands of different stand ages and treatment histories, many of the investigated structures were found to be indicators of natural mature and natural old-growth Douglas-fir stands, with especially bark structures strongly depending on tree diameter and with a characteristic microhabitat composition in natural stands.

Microhabitats have recently been promoted as a monitoring tool after several European studies have tested their applicability in the field. We hereby suggest (1) making the inventory of tree microhabitats mandatory in national and international forest monitoring networks, (2) setting minimum standards for their abundance, and (3) actively managing forests for microhabitats to halter the further loss of forest biodiversity.

Bark structure, Wildlife habitat, Old-growth

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IUFRO17-939 **Quantifying structural complexity as an indicator of biodiversity in heterogeneous forests: Potential of ALS and UAV system.**

Sadeepa, J.* (1); Owari, T. (1); Tsuyuki, S. (1)

(1) The University of Tokyo, Tokyo, Japan

Abstract: Structurally complex forests may respond positively to new or variable conditions, creating more overall stability and sustaining biodiversity in the context of changing environmental conditions. Because of the inherent difficulty in measuring three-dimensional (3D) structure of vegetation using conventional methods, until recently, this important measure has been restricted to limited number of applications. Advanced remote sensing techniques offer improved capabilities for characterization of 3D structure of vegetation. Therefore, present study aims to incorporate information from 3D structure of vegetation when quantifying forest structural complexity, with emphasis on the use of airborne laser scanning (ALS) and unmanned aerial vehicle (UAV) system. ALS and UAV data that were acquired from a mixed conifer-broadleaved forest in northern Japan were used to derive various metrics (height, density, surface area ratio, etc.), then to generate canopy models (canopy height model, canopy density model, canopy roughness etc.) and finally to map structural complexity. Forest structural information derived from ALS and UAV data could greatly contribute when quantifying forest structural complexity in a heterogeneous forest with long disturbance history. Possibility to quantify forest structural complexity effectively using ALS and UAV system would be a critical juncture for global biodiversity conservation as it opens new possibilities in promoting biodiversity through structural complexity.

Mixed forest, airborne laser scanning, Japan

Poster Exhibition Monday

109 - Promoting forest biodiversity through structural complexity? New advances in the assessment and

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IUFRO17-3468 **In retention forestry, which microhabitats are integral for epiphytic species diversity?**

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(1) Albert-Ludwigs-University, Freiburg, Germany; (2) Nationalpark Schwarzwald - Black Forest National Park, Bad Peterstal-Griesbach, Germany

Abstract: Few studies have assessed the importance of forest retention measures for biodiversity in managed temperate forests in Europe. The aim of this study is to determine the effectiveness of retention trees for epiphytes, in multi-functional, mixed forests, using the Black Forest (Germany) as a model. This study falls within the framework of the ConFoBi Research Training Group at Freiburg University.

Epiphytes are one of the most sensitive groups of species to environmental changes, especially as a consequence of forest management. In order to establish which conditions are integral to preserving epiphytic diversity, this study will assess microhabitats (such as cankers, rot holes, fissures etc) on the whole tree, including the crown. Due to time constraints tree crowns are rarely assessed, yet crown-focussed studies have recorded significant epiphytic species diversity, and this data is integral to informing conservation decision-making.

The central hypothesis of this project is that certain microhabitats provide important habitats for epiphytes. This study will explore which species are present within specific microhabitat types, and relate them to environmental factors at different spatial scales. This will enable optimal environmental conditions to be understood and therefore foster better forestry management techniques.

Retention trees, microhabitats, epiphytes,

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2609 **The diversity of dead wood in unmanaged hemiboreal forests of Southern part of Latvia**

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Abstract: Dead wood is one of the most important elements of biodiversity in forested ecosystems: 20-25% of forest-dwelling species are associated with dead wood. It is found that 20-30m3 dead wood per 1 ha is needed to protect existing levels of rare and threatened species in European forests. The aim of this study was to assess the variability of dead wood in different types of forests in Southern Latvia. We established 18 sample plots with size of 20m×50m in swamp forest, deciduous and coniferous forest stands. We measured volumes of all snags, stumps and downed logs. In studied plots volumes reached 48.1m3 per ha in swamp forests, 149.5 m3 per ha in deciduous and 38.2 m3 per ha in coniferous forests. Small diameter dead wood (up to 20cm) was dominant in swamp and deciduous forests, but medium-size dead wood (up to 30cm) was more common in coniferous forests. In all sample plots snags and stumps were mostly in I and II stage of decay. For downed logs in swamp forests I and II stages were the most common, but in deciduous and coniferous stands - II and III stage.

dead wood,hemiboreal forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-751 **Admixed single trees as structural elements promoting faunal biodiversity**

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(1) Institute of Silviculture and Forest Protection, TU Dresden, Tharandt, Germany

Abstract: The restoration of extensive areas of homogenous Scots pine forest is one of the challenges currently facing forest management in central Europe. The emergence of any effect on biodiversity of the addition of tree species in previously pure stands requires a certain time span. Therefore, it is important that all existing individual structural elements can be integrated into stand development measures to enhance biodiversity and to activate related ecosystem services promptly. The focus of the study is on the effects on faunal ecology of the presence of individual sessile oak trees in pure pine stands. These old oak trees (aged between 70-150 years) are long-standing, ecologically important refugia. We used traditional recapture methods to evaluate the spatial and temporal presence of different carabid beetles and their developmental stages and gender in forest stands. The fact that carabid beetles are characterised by individual locomotory activity complicated the subsequent spatial analysis. To facilitate spatial point pattern analysis, we used a random field approach to transform the lattice beetle trap data to point data. The toroidal shift test was used to verify the independence of tree and beetle distribution. The results confirmed that the presence of old oak trees exerts an influence on the occurrence of carabid species, with contrasting effects depending on the beetles' developmental stages and gender. The analysis of the temporal distribution revealed species-specific variations caused by micro-environmental differences. Even single tree admixtures within a very homogenous forest matrix result in complex spatial and temporal ecological niches for carabid beetles. Consequently, these single tree admixtures represent a small-scale focal point of biodiversity. Admixture also serves to generate advanced ecological functions; for example, higher carabid beetle populations that act as antagonists of insect pests.

oak, carabids, spatial and temporal distributions

Poster Exhibition Monday

109 - Promoting forest biodiversity through structural complexity? New advances in the assessment and

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3825 **Functioning of private nurseries and their contribution to the conservation of woody parkland in the province of Kadiogo, Burkina Faso**

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(1) CNRST/INERA/DEF, OUAGADOUGOU, Burkina Faso; (2) Université de Dédougou, DEDOUGOU, Burkina Faso; (3) Université de Ouagadougou, OUAGADOUGOU, Burkina Faso

Abstract: In Burkina Faso, the management of private nurseries is developed in large cities. The main objective of this study is to know the functioning of these nurseries, their contribution to the conservation and restoration of woody species diversity in planted forests and Agroforestry parklands in urban and rural areas of the province of Kadiogo. Specifically, it aims to characterize the management of nurseries; To know the ecosystems of investment of the plants produced and to identify the woody species produced. To do this, interviews were made with 100 private producers from Ouagadougou and Saaba spread over 9 production sites: Nongremassom, public garden, Dassasgho, Zogona, Museum, Ouaga 2000, isolated nurseries, Saaba, dam n ° 1. Interviews and observations were also made on six (06) forest plantation sites. The results indicate a dominance of professional nurserymen. They are producer-sellers and sellers proprietors rarely affiliated to associative structures. The main customers are the local population followed by the external and neighboring countries where retail sales and wholesale. A total of 54 local and exotic woody species are inventoried in private nurseries. They are divided into 42 genera and 23 families. Plants are invested in three types of agroforestry parklands, orchards, reserves and concessions. However, the absence of special production sites, the threats of eviction are the constraints which hinder the development of the activity. Better organization of the actors of the sector, supported by the public structures could allow increasing the activity and generating jobs.

nursery, species diversity, Plantations

Poster Exhibition Monday

171 - Managing Risk in the Face of Uncertain Change

KG II - HS 2121 (Uni Freiburg)

IUFRO17-925 **Accounting for risk in forest management - what is risk and when is risk management useful?**

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(1) University of Jyväskylä, Jyvaskyla, Finland; (2) Natural Resources Finland, Joensuu, Finland

Abstract: The risks of natural hazards are well known in forestry. However, many other sources of uncertainty than the hazards can introduce risk into the decision making. Depending on the decision problem at hand, a given source of uncertainty may or may not introduce the need for risk management. The types of uncertainty can be resource uncertainty, market uncertainty or political uncertainty. Resource uncertainty is the uncertainty of the current state of the forests and the development of the state in the future. Market uncertainty includes uncertainties concerning prices of timber, costs of silviculture and demand of timber. Political uncertainty refers to the uncertainty concerning the laws, taxation and subsidies. We discuss the concepts of risk and uncertainty, sources of uncertainty relevant to risk management and measures of risk. We present decision problems where the decision maker is facing uncertainty and discuss the situations where the decision maker can benefit from risk management and when risk management does not help. This depends on the sources of uncertainty involved and the decision problem at hand. Risk management comes with a price and the willingness to pay for the risk management depends on the risk attitude of the decision maker.

Stochastic programming, Risk, Uncertainty

Poster Exhibition Monday

119 - Quantifying disturbance effects and post-disturbance dynamics with repeatedly measured plots

KG II - HS 2121 (Uni Freiburg)

IUFRO17-516 **Dynamic of a tropical forest submitted to reduced impact logging in Belterra,Pará, Brazil**

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Abstract: The Amazon has a great biodiversity that needs research to ensure its development without the extinction of its natural resources. This study aims to increase understanding of changes in dynamics (recruitment, growth and mortality) of a natural forest under low impact forest logging over a period of six years. The data used in this study came from measurements of the permanent plots of forest management of the Coomflona Cooperative project (Ambé project), located in the Tapajós National Forest, Belterra, Pará, Brazil, where all individuals were measured with diameter at breast height equal or larger than 10 cm (DBH ≥ 10 cm). A forest area of 300 ha was selected, where six plots with a size of 50 x 50 m were installed, obtaining a sampling area of 1.5 ha installed with a completely randomized design. A total of 129 species were found in the forest in the first inventory (2006) and 136 species in 2012. During the monitored period, from 2006 to 2009, the forest showed a decrease of 6.46% in the number of individuals; for the period from 2009 to 2012 there was an increase of 5.78%. The results for the basal area were 30.36 m^2 ha^{-1}, 29.35 m^2 ha^{-1} and 29.19 m^2 ha^{-1} for years 2006, 2009 and 2012, respectively. The volume declined by 3.16% between 2006 and 2009, and by 1.68% between 2009 and 2012. The Periodic Annual Diameter Increment for the period from 2006 to 2012 was 0,38 cm $year^{-1}$. The growth values in basal area and volume for the period from 2006 to 2012, considering all species were 0.49 m^2 ha^{-1} $year^{-1}$ and 6.06 m^3 ha^{-1} year-1, respectively. Considering the whole monitored period, the forest presented a negative balance (0.09%), with the number of dead trees being 12.5 trees ha^{-1} $year^{-1}$ and the recruitment 11.9 ha^{-1} $year^{-1}$.

Forest management, mortality, growth, recruitment

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3919 **The impact of forest fire on survival and growth of the survived scots pine trees**

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Abstract: Background: Wild fires can influence the growth of forest stand at least in two ways: by killing trees and by changing the course of growth of the survived trees.
Aim of study: The present study evaluates stand factors affecting growth of the trees after wild fire.
Area of study: Region throughout Latvia.
Material and methods: Data from the 33 pine stands affected by fire was used. In each stand were measured at least 50 trees. For each tree was assessed degree of impact - burn height, level of root exposure, level of crown damage. Survival of trees was assessed for four seasons. The Cox proportional hazards regression model was used. Eight to ten years after fire 30 trees per stand were cored and radial increment was measured using LINTAB IV. As the control trees for BACI design were used trees growing in the same stand at least 30m outside fire affected area or in the similar stand nearby. For growth similarity assessment method elaborated by I. Liepa (1996) was used. Calibration period (Before fire) was set to 10 years.
Main results: Majority of trees died within first 2 years. Mean 5 year additional cumulative diameter increment (MACDI) of survived trees was negative in all age groups: age group 31-60 years MACDI is -0.96 ±0.56 (±SE)cm, age group 61-90 years MACDI is --1.57 ±0.56 (±SE)cm, age group 90< years MACDI is -1.60 ±0.66 (±SE)cm. Statistical analyses showed that the reduction in the radial increment is a related to height of stem burning. If mean burning height is less than 2m stands can have positive MACDI, while if mean burning height is higher than 2m MACDI is negative. Level of root exposure as well negatively influenced MACDI, despite root exposure was relatively low for survived trees. Annual changes in additional diameter increment varies between stands - from clearly negative trend up to positive trend.

Scots pine, fire, survival, growth

Poster Exhibition Monday

48 - Ecohydrology-based forest management for water provision, carbon sequestration and enhanced

KG II - HS 2121 (Uni Freiburg)

IUFRO17-816 **Initial stand density as an influential ecohydrological factor of mixed forests of Pinus sylvestris and Fagus sylvatica.**

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Abstract: Management of mixed forest has become an adaptation strategy to reduce the risks related to climate change and, at the same time, ecological models can be a useful tool for studying the growth and productivity of these stands. This work introduces an example of sensitivity analysis for different levels of density regeneration, to evaluate the capacity of the 'FORECAST Climate' hybrid model to simulate the estimation of water stress and productivity in mixed pine and beech forests in Navarre (northern Spain). The study included three climate scenarios to test the model capacity to simulate water flows. The model is sensitive to the reduction in the initial regeneration rates by assessing both water stress and biomass accumulation. The results indicated that the model shows sufficient capacity to simulate the effects of competition between species mortality and estimate the variables related to water flows. On the one hand, the most significant effects of stand density on water availability occur during the first stage of development, while on the other, water stress is greater in the case of beech, although the reduction in competition could offset this increase. The implications of this work for adaptive management of mixed forests suggest the current density control in order to have significant cumulative effects in coming decades.

ecological model, FORECAST Climate, tree mortality

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1423 **Responses of soil respiration to forest thinning in semiarid ecosystems**

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Abstract: In order to estimate accurately the global carbon budget it is fundamental understanding the effects of forest management on Carbon fluxes, both from the atmosphere to biomass or net productivity and from soils to the atmosphere through respiration. Traditionally, the forest management has been driven by the increase of the productivity. Nowadays new aims, such as increasing resilience to climatic alterations, are emerging. These alterations are going to be more likely, especially in semiarid ecosystems. There are not clear effects of forest thinning on soil respiration due to the interactions of several processes: thinning diminishes root respiration due to reducing the number of plants, but also changes understory microclimatic conditions affecting microbial respiration. Thinning favours higher radiation reaching the soil, so there is a likely increase in soil temperature and respiration, but soil water could increase due to reduction of rain interception or diminish due to higher soil evaporation. In this work two semi-arid forest areas, (Alepo pine and holm oak) have been selected at Valencia (Eastern Spain). In each one two differential plots were established, one untreated and the other was thinned according to forester's recommendations. In each plot nine collars were installed in three blocks along the slope to measure soil respiration. Soil respiration has been measured approximately at monthly intervals. At the same time superficial soil moisture and temperature (0-6 cm) were recorded. Soil respiration increased with moisture and temperature. Mean annual soil respiration was between 10 to 20% greater in the control plots. Mean respiration values were higher in the hydrological year 12-13 than in the drier 13-14. In general, superficial soil moisture was higher in untreated plots.

Thinning, CO2 fluxes, soil microclimate

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1205 **Effects of air pollution and forest on spring water chemistry on the example of the Polish Carpathians**

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Abstract: The rapid industrialization of Poland in the 1950s and 1960s produced excess deposition of airborne sulfur and nitrogen. The main result of these emissions was damage to tree stands in the Silesia Beskid mountain region (Malinowski Potok catchment). This problem was particularly evident in near-summit areas. Another reason for tree stand damage was hurricane force winds, which were responsible for extensive deforestation in the Tatra National Park. The deforestation occurred in the Koscieliski Potok catchment, which is the only area in the Carpathians with alpine relief. As a reference area without air pollution effect were choosen springs from the Gorce National Park (the Jamne and Jaszcze catchment). The purpose of the study was to identify factors determining spring water chemistry draining small mountain catchments. Water chemistry was determined via ion chromatography: Ca2+, Mg2+, Na+, K+, HCO3-, SO42-, Cl-, NO3- (DIONEX 2000 and 5000).
All the studied springs in the Silesia Beskid Range and the Gorce Range were characterized by very low electrical conductivity, mineral content, and concentration of main ions, especially Ca2+ and HCO3-. According to PCA analysis, the most important factor determining water chemistry in the Silesia Beskid Range was human impact associated with changes in water pH, SO42- concentration, and main ion content. The substantial acidity of the environment resulted in an absence of environmental factors on the list of primary factors affecting the studied region, including discharge. Electrical conductivity was higher for water originating in the deforested catchments of the Tatra Mountains versus that for samples from the Silesia Beskid Range, which may be explained by local geology.
Spring water chemistry in the study area was affected by deforestation, which is seen via the identification of three subpopulations of water samples. This was further confirmed by the analysis of empirical ion density functions, especially those for NO3-.

deforestation, windthrow, water chemistry, Poland

Poster Exhibition Monday

48 - Ecohydrology-based forest management for water provision, carbon sequestration and enhanced

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2342 **The long-term changes in the stand transpiration of Japanese cedar and Japanese cypress plantation after thinning**

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Abstract: Japanese cedar and Japanese cypress are the main species in coniferous plantation and accounts for 40 % of forest covers in Japan. The detail information of tree water use by these species enables us to evaluate water resource availability from plantation catchments after forest management. In this study, we monitored stand transpiration of Japanese cedar and Japanese cypress to compared responses of tree water use to environmental changes due to thinning. We established study plots in the stands of each species, and sap flow was measured to evaluate stand transpiration for four years. In second year, 50 % of trees were removed in entire catchment including both plots. The mean sap flow density did not change in the first year after thinning, so the reduction of stand transpiration in the studied Japanese cedar and cypress stands were reflected by changes in total sapwood area. The annual stand transpiration in Japanese cypress stand were stable for three years after thinning, however, that in Japanese cedar stand increased. It is because Japanese cedar has higher stomatal conductance especially in early spring, while Japanese cypress has constant stomatal conductance throughout the growing season.

Chamaecyparis obtusa, Cryptomeria japonica

Poster Exhibition Monday

118 - Nature-based tourism and recreation´s role in sustaining forests and improving people´s quality of life

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2844 **A Research on Recognition and Needs of Mountain Village Residents to Promote**

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Abstract: This survey was conducted on the mountain village residents' needs and awareness of Eco-tourism. The survey included opinions about introducing Eco-tourism, Residents' willingness to join, types of policies to push forward, requirements to Korea Forest Service and expected outcomes. 346 residents were selected for this survey from 33 mountain eco-villages established by Korea Forest Service and 24 rural experience villages established by Ministry of Agriculture, Food and Rural Affairs, and they respectively participated in this survey through interview from June 17th 2015 to September 17th 2015. Major analysis showed that, about a query on the introduction of mountain village Eco-tourism, 86.7% residents approved this idea, 78.3% residents were willing to participate in Eco-tourism program, and 42.2% responded that cooperation between Korea Forest Service, administration agency concerned and local government is very important to establish an Eco-tourism model. When introducing Eco-tourism, as to the requirements for support in program and service section, 60.4% gave priority to environment and facilities and 67.6% to development program. 86.1% of residents expected that introduction of Eco-tourism would activate the mountain village economy through the increasing number of visitors. This research is expected to provide information in the process of making the mountain Eco-tourism policy.

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Mountain Eco-tourism, Mountain Eco-Village, Intro

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2610 **Trampling effects of orienteering on vegetation in protected areas and production forests in Latvia**

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Abstract: Just like other human-nature interactions sports events outdoors provide challenges from nature conservation standpoint. Orienteering competitions are particularly popular in Latvia and can result in considerable soil disturbance from running. Our aim was to assess the magnitude of disturbance of forests from orienteering competitions especially on EU protected habitats and species in Central Latvia. 20 study sites were established and data were collected to monitor the condition of soil and vegetation cover in protected areas and production forests. Vegetation survey using standard methodology was performed in all plots. In this area where forested dunes dominate, sensitive species are particularly vulnerable. Results showed that there is no significant disturbance to herb layer in any of study plots. The decrease of moss cover was found in few study sites. We also found that the magnitude of disturbance was not correlated with forest type. However, longer studies are needed to better assess the impact of these events on the condition of vegetation development after disturbances.

orienteering, forest soil disturbance, vegetation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1076 **Quantification and regionalisation of recreation values in Germany in the ReWaLe framework**

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Abstract: In our project ReWaLe, which aims for the analysis and interpretation of interactions between several forest ecosystem service values at regional level, we combine GIS (geographical information system) and monetary valuation approaches.
In this presentation we focus on the recreational value of forests in Germany, for which we have gathered monetary valuation data in 2013 in a Germany-wide contingent valuation survey. In order to regionalise valuation data from this population survey, we analyse several parameters including land cover and land use data, as well as forest inventory and sociodemographic information. Furthermore, these parameters are analysed to define and calculate specific explanatory variables as well as model spatial variations. Depending on these regionally differing parameters we can calculate willingness to pay values from the population survey and transfer them to single counties or regions in Germany. From this, we gain insights into trade-offs between recreation and other services provided by forests and valued by the population. We set up a model which visualises these trade-offs and identifies critical regions for political activity.

GIS, valuation, population survey, forest

Poster Exhibition Monday

88 - Natural hazards and disturbance interactions in mountain forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3814 **Effects of defense structures on soil properties and tree regeneration in avalanche starting zones (Valle d'Aosta Region, NW Italy)**

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Abstract: Many active avalanche release areas can be stabilized by man-made structures, such as snow nets and bridges, thus preventing snow glide and initiation of avalanches. These movements can have a negative impact on forest stands, often causing mechanical damage to stems and branches. Moreover they can exert considerable erosive forces on soils, expecially in the release and track areas, while in the run-out zone is commonly observed the deposition of significant amounts of debris. The building of defense structures stops the snow movements, favouring tree regeneration and soil evolution in the avalanche starting zones located below the tree line. The speed of such processes could be variable as a function of site characteristics, such as the nature of the parent material, exposure and slope angle, originating new forest ecosystems, which in the long run can take over the function of the prevention technical measures. Soil and plant characteristics have been investigated in paired sites, one undisturbed and one where the avalanche defense structures have been constructed at different times. The results show how the defence structures significanlty contribute to tree regeneration and soil development, with the genesis of specific pedoenvironments, generally characterized by a long-lasting snow cover. Conversely, the occurrence of snow movements may lead to permanent soil loss and prevent forest regeneration.

erosion, horizonation, protection forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3593 **Extreme runoff and erosion event in a forested alpine catchment**

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Abstract: In the small alpine catchment (~4km²) of the Seigesbach near the village Sellrain in the Stubaier Alps (Western Austria), a debris flow occurred in June 2015. The process extent was limited to the forested part of the catchment (970 - 1800 m a.s.l.). Ten years before, the spruce trees along the channel were cut down, to limit the amount of driftwood in case of a debris flow. To investigate, which areas contributed to the debris flow, the source areas along the channel were mapped after the event with unmanned aerial systems (UAS). Using structure-from-motion photogrammetry, high-resolution orthophotos and digital terrain models were generated. The source areas were identified and classified as stocked or unstocked prior to the event, by comparing the UAS data with historic orthophotos. The results showed that erosion zones outside stocked and unstocked areas were quite equally distributed, but frequently erosion was observed in clear-cuttings on areas of distinct geologic and geomorphologic erosion susceptibility. Erosion zones above of the terrain edge were only observed in combination with forest roads; this shows on the negative impact of sealed areas on high concentration runoff.

Debris flow, driftwood, erosion zone

Poster Exhibition Monday

6 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-891 **Understanding Public Risk Perceptions of Climate Change Effects**

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Abstract: Understanding risk perceptions is a prerequisite for effective climate change communication and adaptation. In the United States, agreement about climate change continues to have sociopolitical roadblocks and, when analyzed as a general operationalization, most Americans report they are not very or not at all worried. By contrast, the research presented in this paper demonstrates higher risk perceptions and greater interest among the public in addressing climate change when the focus is instead on specific outcomes of climate change. In this paper, we discuss findings from several research projects conducted over the last ten years, ranging from wildfire to invasive species to extreme weather - all focusing on risk perceptions of natural hazards. Besides increased salience of physical environmental risks, risk perceptions were associated with de-emphasis of controversial climate change rhetoric, pro-environmental attitudes, political orientation, and positive attitudes about their community of residence. Findings demonstrate that risk perceptions are multi-faceted and complex and are shaped by individual attributes as well as local social interactions. Implications are discussed for how policy-makers, educators, foresters, and other natural resource managers can improve climate change communication and resiliency on public and private forest lands.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2744 **Constructing theory on participation in spatial planning-case study from Nature Park Medvednica, Croatia**

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Abstract: Across Europe, there is disparity between legislative requirements on participation in spatial planning and its implementation. This research tries to assess what kind of role participation had in the creation of spatial plan for Nature Park Medvednica, a protected forest area and Natura 2000 site in Croatia. Since the process lasted more than thirty years, a historical perspective allows an assessment of the participation practices with respect to changing socio-political factors. The research design follows Grounded Theory, where data collection and analysis evolved in parallel until theoretical saturation occurred. Data sources include 51 interview with identified stakeholders, minutes and non-participant observation of six public hearings, historical records, project documentation and expert studies focusing on Medvednica. Results show a strong role of general socio-political factors affecting the design of spatial planning, which in turn shapes the role of participation. The most important general contextual factors are the grade of centralization of the state administration, the grade and process of urbanization, and the culture of participation in decision-making processes. The theory defined in this study links participation practices to its socio-economic framework, outcomes of the spatial planning and perceptions on the role of actors in it - all through 15 assumptions and 46 formal hypotheses proposed.

grounded theory, protected areas, participation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1053 **Collaborating for forest nature conservation? Administrative perspectives**

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Abstract: Calls for close collaboration between forest and nature conservation authorities in the context of nature conservation are not a new phenomenon. Yet past experience has shown that pledges by various actors to work together do not necessarily translate into actual and productive collaboration between authorities during the implementation phase. Sources of disagreement frequently relate to diverging 'frames' among members of different administrative authorities about what constitutes an appropriate measure or what intensity of land use is acceptable. 'Frames' are defined as "mentally stored clusters of ideas that guide individuals' processing of information" Entmann (1993, p. 53).
This study focuses on the state of Baden-Württemberg, Germany, who has recently re-stated its goal to expand the collaboration between the state forest and nature conservation authority at all administrative levels to further nature conservation objectives. We rely on qualitative methods to examine (1) existing 'frames' of nature conservation held by members of forest and nature conservation authorities in the state of Baden-Württemberg, as well as (2) the role existing 'frames' play in past and future collaboration between authorities in the nature conservation context. Results will provide insights regarding existing frames of actors and important factors affecting collaboration of administrative authorities.

collaborative management, Germany, forestry

Poster Exhibition Monday

6 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3669 **Rural realities between policy goals, market forces and natural disasters - a narrative of local forest management in southern Sweden**

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(1) Southern Swedish Forest Research Centre, Alnarp, Sweden

Abstract: Forest owners in Sweden today hold high degrees of individual freedom in their forest management. At the same time, societal demands on forests for material and energy use are increasing, while environmental objectives are not reached. This narrative aims to understand the role of the local context in forest management and in connection to larger-scale societal and sectorial changes. In-depth interviews were conducted with forest owners, managers and other local actors in a highly local case study - a landscape laboratory - located in southern Sweden. The resulting narrative brings forth the high level of interconnectedness and interdependencies between different agents and issues in the local forest management. How ecosystem service production is affected by personal relationships, local tradition and trust is addressed and show the diversity of multi-objective and opportunities for small-scale segregative strategies. The local tradition is however at odds with a more business-like forest management. Natural disasters in the form of two severe storms have had the most profound and direct impact on forest management, changing biophysical conditions and the emotional relationships to the forest. Policy and research can learn from the narrative in terms of better grasp of the complexity underlying forest management decisions and the role of local context.

forest advisory services, trust, rural development

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3377 **Unpacking 'gender' in India's Joint Forest Management**

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Abstract: Gender issues have garnered attention in participatory forest management, particularly in South Asia. Yet, despite reservations for women in local committees, numerous constraints hinder women's active participation in forest governance. Agarwal's seminal work on participation in an Indian Joint Forest Management (JFM) context underscores that participation on paper, as stipulated by JFM policies, can differ from active and meaningful participation in practice. Understanding participation in JFM requires careful attention not only to gender but to the diversified interests and experiences women hold. Based on 85 semi-structured interviews with women and men farmers, JFM committee members, local authorities, NGO staff and Forest Department officials, we explore how social differentiation shapes participation in JFM. We compare the situation in Karnataka, a wealthier Indian state that holds a high proportion of upper caste residents and is exemplary for JFM, with that in Madhya Pradesh, a poorer Indian state dominated by tribal communities where JFM is poorly functional. We show that among tribal groups, women of certain ethnicities are particularly disadvantaged, despite their extensive forest knowledge. We argue that understanding differentiated interests, constraints and opportunities in JFM requires understanding gender in relation to other factors of social differentiation.

social differentiation, equity, participation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3801 **Traditional local knowledge and agroecological and biological conservation practices under climate change uncertainties in the Centre-South regions of Cameroon**

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Abstract: This case study documents thee socio-cultural roots of the local and traditional knowledge and practices in agroecology face to scientific to support agro-ecological resilience of Centre-South regions of Cameroon. In these regions, forest-dependent communities practice forest agriculture based on agricultural land uses, fallows, tree crop plantations and forests, ensuring social control of lands and resources and the mobilization of financial resources for family livelihoods. Building on the agro-ecological practices prevailing in the study areas, and on the basis of theory, observations, interviews and participatory system analysis through a workshop with the custodians of traditional/local knowledge and agro-ecological practices. The findings show that environmental and climatic changes are perceived through the behaviour of local bioecological indicators including weeds, shrubs insects, animals such as birds and trees. Local indicators are used to interpret changes in order to predict and anticipate uncertainties associated with environmental and climate changes; the seasons and weather are the determining factors for the organization of socio-economic activities necessary to achieve life goals. Local adaptation practices undertaken in response to environmental and climate uncertainties, and are applied depending on the nature of the impacts and the knowledge of their causes. The results also show that the articulation of the agricultural cycles to agro-ecological units is based on an integrated "agroforestry" approach combining food crops, domestic fruit trees and non-domesticated resources. This approach is the foundation of the resilience of indigenous and traditional agro-ecological systems and provide key points that could mark a new era in the valuation of traditional knowledge in a context dominated by the interest-based approaches at the expense of the rights-based approaches for the sustainable management of biodiversity and life: a planetary challenge.

Climate, uncertainties, adaptation, practices

Poster Exhibition Monday

6 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3959 **A 'Citizen's Coolkit' on climate change and urban forestry - Canadian experiments in co-creation and experiential learning at the neighbourhood block scale**

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Abstract: Climate change threats, development pressures on urban forest canopy, and growing public expectations for inclusion in decision-making mean that we will need more engaged and informed citizens to play a role in maintaining a healthy urban forest. Existing volunteer programs do not reach the majority of residents who control the private portion of the urban forest. How can we scale up and deepen citizens' engagement in urban forestry? Research suggests this would require invoking peer pressure/competition, gamification, place attachment, and experiential learning in a process of co-creation of local knowledge. Citizen science offers expanded opportunities for engagement, using interactive exercises and/or mobile technology. This presentation introduces a 'Do-It-Yourself' toolkit of activities for neighbours working together to gain a better understanding of the values of urban forests/trees on their block, through various fun inventory and evaluation activities. Researchers in British Columbia have initiated experiments to develop and test this prototype "Citizens Coolkit" for engagement on urban forestry and climate change, at the seldom targetted residential block scale. Activities are organized in a 5 step process: starting a conversation; mapping the block; rating the block; future visioning; and action planning. Early research results and directions for further evaluation will be outlined.

climate change, citizen science, urban forestry

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3379 **The community forestry enterprise in the central region of Mexico: a study case of determinants of success**

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Abstract: In the community forest enterprise (CFE) in the region of the Monarch Butterfly Biosphere Reserve (RBMM), one of the 177 protected natural areas of Mexico, there is a progressive deterioration of natural resources. For this reason it is important to revert this process. The objective of this research was to know the determinants of success of the CFE in the RBMM in order to design appropriate public policies for the sustainable use of the forest resources. A leading CFE (San Juan Xoconusco) was compared to a less developed CFE representative of the Reserve. For this purpose, the Strategic Analysis was used under the "Diamond of Porter" scheme. Also we used a structured and semi-structured survey, the spatial analysis in a digital platform and the analysis of social and economic indicators. The results indicate that social capital (e.g., communal silvicultural activities in the first links of the forest production chain, maintenance and forest protection) and human capital (e.g., communal silvicultural activities, self-government practices, customs and customs, loyalties and communal identity) were the determinants of success of the leading CFE. Therefore, any government initiative that promotes forestry in the RBMM should be based on the consent and forestry culture of the forest community.

Analysis, community, human capital, success

Poster Exhibition Monday

8 - The Role of Social Science in Forestry and Forest Management: Fostering a Culture of Disciplinary

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3893 **Innovative forest stakeholder mapping: Where vipers and trees do have a stake**

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Abstract: Forestry and forest sciences are dealing with the use of natural resources and are therefore confronted with social and economic demands. In urban regions multiple and differentiated societal desires and needs still increase and are putting pressure on green areas and forests and its managers. Until now however, sociological contributions and governance perspectives in forestry research are rare. Also the interrelation and structural parallelism of social and biophysical dimensions play a key role for a sustainable and future-oriented forestry.

Use-inspired basic research is needed for overcoming the actual paradigm of a separation of social and natural sciences and practice. We are proposing an integrative stakeholder mapping tool where actors with variable interests and power from the human and environmental "world" are analysed, following the idea of the Actor-Network-Theory. Moreover, the value and harm added on each stakeholder is evaluated in order to assign importance to non-vocational but often highly affected and usually neglected human and non-human actors.

By opening the much focused perception of forest decision makers we aim to put forestry toward a sustainable future overcoming traditional thinking pattern and constraints. The presentation will highlight the contribution of social and sustainability sciences to forestry and give examples from the practical field.

integration, stakeholder analysis, actors

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1048 **Forest policy implementation in the Pacific Northwest - a street-level perspective**

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Abstract: US forest policy changed drastically during the 1990s and fundamentally altered National Forest management in the Pacific Northwest. Through the Northwest Forest Plan, the previous emphasis on timber production was replaced with a broad set of objectives and collaborative management approaches started to become increasingly important. Yet today's institutional setting continues to be characterized by old dynamics, e.g. regarding budget structures or planning processes. The convoluted nature of the current forest governance system's emergence raises the question of how forest policy is actually implemented at the local level. We rely on 32 qualitative interviews with various actors involved in public forest management at the district level on the Siuslaw and Willamette National Forests in Oregon to understand what is driving public forest management decisions today. We find that forest management currently takes place in a vetocratic and neo-liberal institutional setting: the implementation of projects is contingent upon getting past numerous veto players; at the same time, the federal government is increasingly withdrawing from its commitments to adequately fund the agency's non-fire operation. As a result, we expect forest management in the Pacific Northwest to vary depending on a districts' distinct social, economic and political context.

public forest management, vetocracy, forest polic

KG II - HS 2121 (Uni Freiburg)

IUFRO17-918 **Estimation of potential forest-cutting sites for environmental preservation in the subtropical forest of Okinawa Main Island**

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Abstract: Subtropical evergreen broad-leaved forest region called Yambaru area is located in the northern part of Okinawa Main Island. This forest has a precious ecosystem with many endemic species of flora and fauna. Hence, Yambaru National Park was established in 2016 as the 33rd national park in Japan to protect its biodiversity. However, this area is also the center of Okinawa forestry and covers approximately 60% of the private forest area in Okinawa Prefecture. Therefore, a forest management system is required to maintain a balance between environmental preservation and local agricultural and forestry development. This study aimed to estimate the potential forest-cutting sites to maintain sustainable forest management. The study area comprised approximately 4,000 ha of forest area located in the Kunigami village, which is a part of the Yambaru area. We initially investigated the political and environmental factors, such as land use regulation, zonation of the national park, soil physical properties, and topographic factors, related to forest cutting. Following this, we estimated the location of potential forest-cutting sites with respect to environmental preservation and forestry. Consequently, we found that the potential forest-cutting sites accounted for almost 50% of the study area, which exhibited forest growth of 3,000 m^3/year. According to the records of the forest owner's cooperative in this area, the total volume of forest cutting is an underestimation of our calculated value. It is suggested that both the amount of forest-cutting volume and the spatial configuration of the forest-cutting sites are important to maintain sustainable forest management in the future.

GIS, National Park, Yambaru

Poster Exhibition Monday

8 - The Role of Social Science in Forestry and Forest Management: Fostering a Culture of Disciplinary

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3128 **Professional ethics as a necessary means for affective, sufficient and sustainable forestry and its examination in forest engineering**

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Abstract: As the modern societies make progress in various fields such as technology and economy; it is seen that these societies are unable to transform these progresses in social life. The rapid development processes these societies experience have brought about embracement of an idea to see the right to do anything and to assume everything fair in reaching the success and ethics has been shattered. The reflection of these problems onto occupational activities has enhanced the anxiety; and efforts to see through the heart of these problems and to prevent them has brought into question ethics which constitutes a discussion in every field today.
Professional ethics consists of rules and principles that guide members of a profession through occupational activities. These principles help members of a profession build and preserve an occupational identity by explicitly setting forth the qualifications required from a member. Members of a profession are in communication with their associates, groups of interests and benefits; and the whole society and therefore should be attentive to their behaviours to preserve dignity and honour of themselves, their associates, the society which they serve and their profession. Besides, a peaceful work environment for associates is formed through featuring principles such as justice, honesty, information sharing, solidarity, love and respect in occupational activities and this brings about efficient and affective work and qualified service encounter in enterprises or institutions. The society put trusts in profession or institution when it knows ethics are being considered in service encounter and thus the profession earns esteem.
This study will examine necessity and importance of rules and principles of professional ethics for forest engineers who manage the forest ecosystems that produce many compulsory and irreplaceable benefits, trends and services in sustainable administration and management of forest ecosystems.

Ethics, Professional Ethics, Forest Engineering

Poster Exhibition Monday

57 - Invasive Alien Species and International Trade - Detection Prior to Introduction, Measures and Policy

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3867 **A Survey of Phytophthora species on Rhododendron plants in Lithuania**

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Abstract: International trade of plants and plant products is now generally accepted to be a major pathway for the introduction of non-native plant pathogens. The genus *Phytophthora* currently includes wide range of species, which cause severe epidemics all over the world. However, there is no detailed information about distribution of *Phytophthora* species in Lithuania. Taking into account the significant economic and ecological threat, we started our study on *Rhododendron* plants because of two reasons: i) these plants are non-native, introduced ornamental plants in Lithuania; ii) plants from this genus are well known as susceptible hosts to the diseases caused by oomycetes. Thus, the main aim of our study was to gather information on the occurrence of *Phytophthora* spp.
A total of 16 genus of *Rhododendron* plants and one genus from *Pieris japonica* were investigated. During the 2016th spring-summer samples from parts of diseased plants roots, rhizosphere soil and nearby water reservoirs were subjected to the study. Direct isolation and baiting-tests on *Rhododendron* leaves was done from collected material. Altogether, we were able to grow 369 pure cultures, where 242 of them were assigned to the oomycete group. DNA from pure cultures of isolates was extracted using Phire Plant Direct PCR Kit (Thermo Scientific, Lithuania). Performed PCR reactions using genus specific primers (Yph1F/Yph2R by SCHENA et al., 2008) approved that some tested rhododendrons are infected by *Phytophthora* spp. Species composition of causal agents on the introduced plants in Lithuania will be clarified.

invasive pathogens, Rhododendron, Phytophthora spp

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2558 **Ceratocystis platani is Responsible for the Death of Plane Trees in Istanbul**

Dogmus- Lehtijärvi, H.T.* (1); Oskay, F. (2); Lehtijärvi, A. (3); Aday Kaya, A. G. (4); Santini, A. (5); Woodward, S. (6)

(1) Suleyman Demirel University, Faculty of Fforestry, , Department of Forest Protection, ISPARTA, Turkey; (2) Çankiri Karatekin University, Faculty of Forestry, Çankiri, Turkey; (3) Bursa Technical University, Faculty of Forestry, Bursa, Turkey; (4) Suleyman Demirel University, Yenisarbademli Vocational School, Cumhuriyet, Turkey; (5) Consiglio Nazionale delle Ricerche, Sesto Fiorentino, Florence, Italy; (6) University of Aberdeen, Institute of Biological and Environmental Sciences, Aberdeen, United Kingdom

Abstract: Canker stain (wilt) caused by the aggressive ascomycete Ceratocystis platani, has killed tens of thousands of Platanus trees in urban and rural environments in the eastern USA, California, and southern Europe. The pathogen is native to the south-eastern USA and was probably introduced to Italy and France in woody packaging materials during World War II. Although the disease initially spread in these two countries, it has now also been confirmed in Switzerland, Greece, and recently in Albania. Spain may be free of the disease after eradication efforts. During investigations of severe dieback and mortality of Platanus x acerifolia and P. orientalis in Istanbul in 2016, Ceratocystis platani was detected in many trees. C. platani was identified based on morphological characteristics in culture and ITS sequencing, confirming this new record in Turkey. Pathogenicity was proved by inoculation on shoots of P. orientalis and the causal agent re-isolated from symptomatic tissues. P. orientalis has an eastern Mediterranean/west Asian natural range: the spread of the disease eastward put this species at risk of extinction since, so far, it has shown little resistance to the disease. Halting the eastward expansion of the disease is now of primary concern for P. orientalis conservation.

Cancer stain, Oriental plane, London plane

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1127 **Invasive alien species arriving to Siberia with national and international commodities: an overview**

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Abstract: Isolated regions with continental climate are not spared from the arrival of alien species, including quarantine pests. Here we present an overview of alien species (arthropods and plants) detected in various commodities imported to Krasnoyarsk (Siberia, Russia) through national and international trade. In the period 2007-2016, hundreds of cases of imports of alien species with vegetables, fruits, grain crops, cut flowers and plants for planting have been recorded. Among the alien species accidently imported to Krasnoyarsk, the following quarantine species of insects and plants have been regularly documented: cowpea seed beetle Callosobruchus maculatus, San Jose scale Diaspidiotus (Quadraspidiotus) perniciosus, western flower thrips Frankliniella occidentalis, oriental fruit moth Grapholita molesta, peach fruit moth Carposina niponensis, common ragweed Ambrosia artemisiifolia, Russian knapweed Acroptilon repens and dodder Cuscuta sp. In about 60% of the cases the interceptions of the quarantine species were made on commodities that arrived in Krasnoyarsk with air cargo, the others came with trucks and railway transport. In 65% of the cases, the quarantine species came from Asia (mainly Middle Asia), 17% from Europe (mainly Netherlands), 12% from South America and Africa, whereas the remaining 7 % came with commodities from other regions of Russia. We will discuss the probability of establishment and possible threats of some of these alien pests in Siberia.

alien species, international trade, Siberia

Poster Exhibition Monday

57 - Invasive Alien Species and International Trade - Detection Prior to Introduction, Measures and Policy

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1445 **A survey for Sirex noctilio and native wood wasps in Alabama**

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Abstract: Sirex noctilio is a wood wasp species native to Europe and invasive in Australia, South Africa, South America and the Northeastern United States. This pest is known to cause significant economic and ecological damage, and mortality of previously healthy trees. Females cause damage to Pinus species by using their ovipositor to drill into the xylem and deposit eggs, venom, and a mutualistic fungus, causing trees to begin to die within days of inoculation. In 2014, a survey for Sirex prevalence was conducted on Tuskegee National Forest. In 2015, sites at Talladega National Forest and Auburn University's Solon Dixon Center were incorporated into the study. Traps were baited with a mixture of kairomones determined to specifically attract siricids. Traps were collected as insects emerged, and were morphologically keyed to species level. The specimens were later dissected in order to sample for symbiotic fungi and the nematode carried in their abdomens. Fungal isolates, nematodes, and wasps were all molecularly analyzed in order to accurately portray species collected, and phyologenetic trees were drawn to display the species diversity captured. Pests that potentially occupy the same ecological niche as S. noctilio were cataloged to determine potential competition. A survey to determine whether S. noctilio has reached Alabama is necessary as there is a risk of invasion via the port of Mobile.

Poster Exhibition Monday

56 - Modern approaches in evaluating ozone impacts on forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1279 **Drought and ozone interactive effects on ectomycorrhizal communities of oak seedlings**

Straus, I.* (1); Mrak, T. (1); Grebenc, T. (1); Unuk, T. (1); Kraigher, H. (1); Hoshika, Y. (2); Carriero, G. (2); Paoletti, E. (2)

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Abstract: Drought is considered one of the most important stressful environmental conditions that is a constrain to plant survival. Mycorrhiza improves the assimilation of water and nutrition for plants, and enhances resistant ability to drought. Second important environmental stress is ozone, which seriously affects Mediterranean vegetation. O3 triggers physiological changes on leaves that affect carbon source strength, i.e. the amount of carbon available for allocation to sink tissues. Decreased carbon allocation belowground affects roots and root symbionts. Contrasting responses to a combination of O3 exposure and drought are often reported in the literature. In our study, drought and ozone response of ectomycorrhizal (ECM) communities in seedlings of three oak species (Quercus ilex, Q. pubescens, Q. robur) was studied at a free-air O3 exposure facility in Mediterranean climate (Sesto Fiorentino, Italy). To achieve best possible identification of ectomycorrhizal types, a combination of morpho-anatomical and molecular tools was used. In total, 15 taxa were identified by molecular methods, 6 of them to the species level. The most common taxa were Tomentella sp.2, occurring in 80% of seedlings, and Sphaerosporella brunnea (64 %). Ten taxa occurred in fully watered conditions, and only 5 in drought conditions. At ambiental ozone levels we recorded 12 taxa, while at 1.5 x ambient level, 10 taxa were found. A significant effect of water x ozone interaction (p=0.0264) was detected for a total number of identified ECM taxa per seedling.

ectomycorrhizal fungi, oak, phylogenetic analyses

Poster Exhibition Monday

300 - Pine pitch canker - strategies for management of Gibberella circinata in greenhouses and forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3714 **The role of primary metabolism and hormone signalling in pine defence responses against Fusarium circinatum**

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Abstract: *Fusarium circinatum*, the causal agent of pine pitch canker disease, has been spreading worldwide. In Europe, it is currently recommended as a quarantine pathogen, threatening natural and planted pine stands. However, little research has been conducted regarding pine defence mechanisms against *F. circinatum* attack. We studied the effect of *F. circinatum* on pine primary metabolism and hormonal dynamics and how this impacts plant defence. An experiment was carried out to evaluate the response of 3 pine species (*Pinus pinea*, *Pinus pinaster*, and *Pinus radiata*) with different levels of susceptibility to *F. circinatum*. Several aspects of the morphological and physiological status of plants after pathogen infection were evaluated (e.g. lesion length, water relations, photosynthesis, total sugar content), together with hormone quantification (ABA, SA, JA, IAA). The expression profiles of specific genes involved on primary metabolism and plant defence strategies were also investigated. The data obtained pinpoints species-dependent changes on photosynthesis, carbohydrate metabolism and hormone crosstalk caused by *Pinus-F. circinatum* interaction. Our results answer to fundamental biological questions, contributing to fulfil the knowledge gap on the mechanisms behind *F. circinatum* infection, and suggest new directions to be explored in order to further manage pine pitch canker disease.

phytopatology, pitch canker, plant physiology

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2214 **Molecular characterisation of chromosome 12 from members of the Fusarium fujikuroi complex**

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Abstract: Species within the Fusarium fujikuroi complex (FFC) are known to have 12 chromosomes, with the twelfth chromosome being dispensable and considered part of the accessory genome. Little information is known about this chromosome, with suggestions that it could possibly be involved in pathogenicity and niche adaptation, even though it is known not to be essential for pathogenicity in F. fujikuroi and F. circinatum. Genomic sequence data is available for a representative subset within this complex, namely F. circinatum, F. temperatum, F. subglutinans, F. fujikuroi and F. nygamai. Chromosome 12 data for each species was obtained using a sequence and genic similarity approach. Analysis of the sequence, genic content and identification of gene functions was undertaken. Sequence similarity, GC content and gene density was low, when compared to that shared amongst other chromosomes within this complex. Genes are primarily involved in oxidation-reduction and macromolecule metabolic processes, cation and nucleoside phosphate binding, and as intrinsic components of membranes. Several carbohydrate active enzymes were detected on each chromosome 12 examined, as well as a secondary metabolite cluster in each of F. temperatum, F. subglutinans and F. nygamai. All these point to the plasticity of these chromosomes within the FFC.

Chromosome 12; Fusarium fujikuroi complex (FFC)

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3094 **Gene gain and loss shapes the evolutionary history of the pitch canker fungus, Fusarium circinatum**

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Abstract: *Fusarium circinatum* is an important pathogen of *Pinus* spp. in commercial and natural occuring forests worldwide. Evolutionary events, such as the gain and loss of genes contribute to intra- and interspecies diversity and enable organisms to adapt to new niches, acquire new physiological traits and, in the case of pathogens, overcome host resistance. Little is known regarding how gene gain and loss changed the gene content of *F. circinatum* or how this might have influenced its evolution. The aim of this study was to assess genome fluctuation in *F. circinatum* by determining gene gains and losses in comparison to nine other *Fusarium* species. The functions of genes that were gained and lost as well as their role in processes such as plant host interactions, carbohydrate active enzymes and fungal effectors were also identified. Gene gain and loss was widespread in *F. circinatum* with 610 genes gained and 496 genes lost since divergence from the most recent ancestor. These changes in gene content corresponded to important biological and molecular functions. Functional annotation revealed that 67 pathogenicity-related genes had been acquired and 63 lost during the evolution of the pathogen. Furthermore, 64 gains and 63 losses were observed for genes identified as potential effectors. Overall, results of this study have shown that a high rate of gene loss and gain have occurred throughout the history of this economically important fungus. Each of these changes represents an important evolutionary event, that could have contributed to its role as a pathogen of pine trees worldwide.

Fusarium circinatum, Pitch canker, genome

Poster Exhibition Monday

300 - Pine pitch canker - strategies for management of Gibberella circinata in greenhouses and forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1198 **Susceptibility of coniferous tree-species of Czech provenances to the pathogenic fungus Fusarium circinatum**

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Abstract: Pine Pitch Canker (PPC) disease, caused by Fusarium circinatum, is a worldwide destructive disease. Dispersal of F. circinatum spores occurs through wind, insect vectors, water splash, soil and movement of infected plant material. F. circinatum transmission in the ecosystem is highly likely being affected by global climate change. All these factors may result in diversification of its host range in Europe. Therefore, the goal of this study was to test the susceptibility of different conifer tree species to PPC (Pinus sylvestris, Picea abies and Larix decidua). A wound was made with a scalpel 5-7 cm above the collar of the 1.5-3.5-year-old seedlings and inoculated with conidial suspension with a concentration of 50 or 1000 spores/ml. 25 seedlings per each species were inoculated with this suspension and other 25 seedlings per species only with distilled water as a negative control. The seedlings were incubated in phytotron chambers under a controlled regime of temperature and illumination. Necrosis length of tested seedlings was measured and observed weekly. Results of this experiment point out the susceptibility of the tested species according to the symptoms development.
This work was supported by projects LD15046 "Detection and biology of Gibberella circinata - essentials for early warning and management strategies in the Czech Republic" and by STSM of COST action FP1406 "Pine pitch canker - strategies for management of Gibberella circinata in greenhouses and forests (PINESTRENGTH) ".

F.circinatum, PPC, G.circinata, Conifer, Suscp.

Poster Exhibition Monday

59 - Responses to the increasing threat of insect pests to sustainable plantation forestry

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1516 **Characterization of the complex wasp community in Leptocybe galls on Eucalyptus**

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Abstract: *Leptocybe invasa* is an invasive gall wasp and pest on *Eucalyptus* trees. This pest has become widely distributed in Africa, Asia, Europe and the Americas. The galls induced by this wasp are also inhabited by other wasps. In South Africa, this includes an introduced biological control agent, *Selitrichodes neseri*; two known parasitoids that were not intentionally introduced, namely *Megastigmus zebrinus* and *Quadrastichus mendelli*; *Megastigmus pretorianensis*, whose role in the gall is uncertain; and an undescribed, cryptic sister species of *Leptocybe invasa* that was recently discovered. To determine the distribution and prevalence of these species, a national monitoring scheme was initiated, where galled material was sampled from infested sites across South Africa, and emerging adults collected and identified. Species specific primers and restriction fragment length polymorphisms were used to identify species and lineages when this could not be done using morphology. The result from the pilot trial of the national monitoring indicates that *S. neseri* and the *Megastigmus* species have spread throughout South Africa, but *Q. mendelli* has a limited distribution. The characterization of the distribution and local frequency of the two *L. invasa* strains, as well as the role of the different gall-inhabiting species, is ongoing

gall wasps, DNA markers, invasive

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2861 **EGG PARASITISM OF THAUMASTOCORIS PEREGRINUS (HEMIPTERA: THAUMASTOCORIDAE) AFTER STORAGE AT 5ºC BY CLERUCHOIDES NOACKAE (HYMENOPTERA: MYMARIDAE)**

Barbosa, L. (1); Rodrigues, A.* (2); Junqueira, L. R. (3); Wilcken, C. (4); Foerster, L. A. (2)

(1) Brazilian Agricultural Research Corporation, Colombo, Brazil; (2) Universidade Federal do Paraná, Curitiba, Brazil; (3) Instituto de Estudos e Pesquisas Florestais, PIRACICABA, Brazil; (4) Faculdade de Ciências Agronômicas - UNESP, Botucatu, Brazil

Abstract: The egg parasitoid Cleruchoides noackae is used in Thaumastocoris peregrinus biological control in Eucalyptus spp. plantations. In order to optimize the parasitoid rearing in laboratory different egg storage periods were evaluated. Fresh eggs of the host were stored at acclimatized chamber (5 ± 2ºC, 60 ± 10% RH, in dark) by 0 (control), 15, 30, 45 and 60 days with 20 repetitions with 10 eggs per treatment. After these periods, T. peregrinus eggs were transferred to acclimatized room (24 ± 2ºC, 60 ± 10% RH and photoperiod of 12 hours) and offered to paired C. noackae females in polystyrene flasks. The parameters evaluated were rate of parasitism, emergence, sex ratio and development time (egg-adult) of C. noackae during two generations. The egg storage of host affected the evaluated parameters of C. noackae. Percentage of parasitized eggs (55%) and adult emergence rate (48%) from eggs stored at 5 °C for 15 days did not differ statistically between the treatments. The parameters evaluated on the second generation did not differ statistically between the treatments. Eggs of T. peregrinus stored at 5 ºC for 15 days may be used in mass rearing of C. noackae in laboratory

Egg parasitoid bronzed bug eucalyptus cold storage

Poster Exhibition Monday

116 - Forest and Natural Resources Policy and Governance in Latin America and the Caribbean

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3337 **Grades of environmental fragility for planning of a watershed soil use**

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Abstract: Studies on the natural support condition of the environment, measuring parameters such as land slope, soil classes and climatic conditions to which a river basin is subjected, allow us to obtain information that, associated, results in predicting and classifying the grade of environmental stability, called Potential Environmental Fragility. Its grading, which ranges from very low, low, medium, high and very high, is based on the set of biophysical characteristics and the risk of destabilize the environment. Combining the classes of Potential Fragility with the anthropic uses and occupations we obtain the classes of Emergent Fragility, that is, predictions to the land manager about which actions will result in a condition of stability or instability, presenting regions where the risk emerges and corrective management is required. These analyses are important to the choice of uses and occupations compatible with its sustainability which promotes environmental stability and safeguard lives. In order to identify the condition of Potential and Emerging environmental fragility, biophysical data, soil use and soil occupation after anthropogenic actions were used in 19.2km² of the Ribeirão da Divisa Watershed, a tributary of the Iguaçu River. Map editing and algebra were performed in ArcMap. The results show that there was a change in the grade when comparing the expected fragility of the basin under natural conditions with the conditions resulting from the use and occupation of the soil without sustainable planning. The basin area of Potential versus Emergent environmental fragility changed: the very low and low grade area was reduced from 89% to 69%, mean grade evolved from 14.5% to 40% and the area of strong grade evolved from 0.15% to 3.3%. The very strong grade was not found in this study. The results show that anthropogenic action without planning impaired the environmental stability of the watershed.

Potential and emerging environmental fragility

KG II - HS 2121 (Uni Freiburg)

IUFRO17-988 **The Compensation of Legal Reserve in Conservation Units: Background, Challenges and Opportunities**

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Abstract: Context

The Brazilian Forest legislation requires all private rural properties to maintain a fixed proportion of their area as forest in the form of a Legal Reserve. However, Forest Law No. 12,651/2012 provides mechanisms of flexibility for landowners who, as of 22 July 2008, did not have the area-based conservation requirements of the law, by compensating this Legal Reserve deficit in other properties. Two of these possibilities involve Legal Reserve compensation (CRL) in a Conservation Unit (CU), such as i) the donation, to the public authority, of an area located inside the CU pending land regularization, and ii) the issuance of an Environmental Reserve Quota - termed as CRA - existing in a rural property located inside a CU that has not yet been expropriated.

Specific problem
The adoption of the above mechanism in CUs has generated much controversy among the stakeholders involved with their implementation. In this context, the purpose of this article is to evaluate the challenges and potentialities of these two compensation instruments.

Methods
Bibliographic review of literature; analysis of the database of the Rural Environmental Registry System and semi-structured interview with experts.

Main results
The two compensation mechanisms in CUs are seen by experts as different between each other, and there is more support to the implementation of a compensation system based on land donation rather than the issuance of CRA within a CU. The donation mechanism is seen as able to bring real benefits to the environment by promoting land regularization of CUs. On the other hand, the issuance of CRA is considered to be a mechanism prone to generate juridical problems.

Conclusions
Both compensation mechanisms involving CUs have been adopted in a pragmatic environmental policy perspective due to the State's lack of capacity in promoting land regularization. These are not ideal mechanisms, however, they might bring environmental benefits depending on how they are implemented.

Land Regularization, Legal Reserve

Poster Exhibition Monday

179 - Forest policy and governance: research at multiple scales

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4026 **The actor-centred analytical approach (Aurenhammer) in forest policy analysis**

Aurenhammer, P.* (1)

(1) Bavarian State Institute of Forestry & TUM, Freising, Germany

Abstract: The poster will describe and discuss Aurenhammer's (2011, 2013, 2014) 'Actor-centred Analytical Approach' (AAA). It will describe its methodological concept, the mixed methodical approach used (quantitative and qualitative analyses) and will discuss differences to some other analytical appraoches.

For a more practical understanding of the application of the AAA, (empirical) examples from international forest policy research (development policy and European forest initiatives) will be chosen.

While the first development and application of the AAA dates back to 2008-2011, with a focus on forest development policy and projects, some further developments of the approach were made for its application on forest initiatives within Europe.

actor-centred analytical approach; policy analysis

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IUFRO17-1217 **Assessing the Value of Forest Cover on Water Quality: An application to Portugal**

Cunha-e-Sá, M. A.* (1); Faria Lopes, A. (2); Quinteiro, P. (3); Carvalho-Santos, C. (4); Dias, A. C. (3)

(1) NOVA School of Business and Economics, Lisbon, Portugal; (2) University of Stavanger, Stavanger, Norway; (3) Centre for Environmental and Marine Studies (CESAM), Aveiro, Portugal; (4) CIBIO-InBIO, University of Porto, Vairão, Portugal

Abstract: Forests worldwide provide a variety of ecosystem services such as carbon sequestration, biodiversity conservation, soil and water protection, which enhance human well-being. In particular, water protection provided by forests ensures quality of drinking water, moderates water and nutrient flow and prevents desertification. The relative low intensity of forest management operations, i.e. the minimal use of pesticides and fertilizers and emissions to water and soil, can result in low impacts in water quality at the watershed level. Investment in green infrastructure by maintaining forests and enhancing reforestation, as opposed to building water treatment plants, reduces costs of clean water supply and wastewater treatment. Replacement costs and contingent valuation techniques have been used to capture the value of watershed protection. This paper uses panel data at the municipality level to assess the marginal effect of land use, in particular, forest cover on water treatment costs for the case of Portugal. No such assessment has been done to date for Portugal. Preliminary results show a positive and significant effect of forest cover on water treatment cost savings. These findings may contribute to improve the options for land and watershed management, namely the development of incentives such as payments for ecosystems services.

forest cover, water quality, valuation

Poster Exhibition Monday

43 - In the woods of transdisciplinarity: Forest science between ´research for the sector´ and a new wave of

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IUFRO17-3437 **Participatory development of indicators for urban forests' ecosystem services. A German case study**

Jay, M.* (1); Selter, A. (2); Schraml, U. (3)

(1) Marion Jay, Berlin, Germany; (2) Professur für Forst- und Umweltpolitik, Universität Freiburg, Freiburg, Germany; (3) Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg, Freiburg, Germany

Abstract: Forest ecosystems provide outstanding goods and services for the well-being of citizens, such as clean air or water, open spaces for recreation, carbon sequestration etc. But how to raise awareness for and assess urban forests' ecosystem services (ES)? Existing indicators of ES have been primarily developed at a national or supranational level. However, the relevance of ES as well as the available datasets vary greatly from one region to another. Until now, ES are rarely integrated within decision making processes, nor are they systematically assessed.
Considering this, a case study developed ES indicators in a transdisciplinary and participative process in four North Rhine-Westphalian cities, being Bochum, Essen, Remscheid and Cologne. In each city, experts from various fields such as forest management, water, climate or education discussed upon and rank suitable indicators. Afterwards the results were analysed during regional meetings and summarized in a practical guideline. The methodology grounds on the participative TEEB methodology (The Economics of Ecosystems and Biodiversity). The iterative nature of the discussion process and the inclusion of various disciplines are critical factors of success. The process and its results show that a transdisciplinary discussion can enhance the visibility of ES at a local and regional level.

Urban forests; ES; indicators

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IUFRO17-4168 **The experience of Uruguay on forest research innovation.**

Scoz, R.* (1)

(1) INIA, Programa Forestal, Tacuarembó, Uruguay

Abstract: Forest research in Uruguay is a relatively new matter considered since half a century by the academic institutions. For a "forest time scale" is this time a very short one. And for stakeholders that have to be phase in generations, means at least less than two.
1963 began the first forest science lessons as an orientation or specialization by the Forest Science Department at the Agricultural Sciences Faculty. 20 years before, started a technical training curricula to prepare people in forest silviculture at a praxis level. Since 2014 exists an exclusively forest 5-years graduate program.
1968 and 1988 the government of Uruguay proclaim by law the protection, the improvement, the enlargement and the afforestation of woodlands. The second proclamation moved the country to a significantly increase of planted forests and the respectively development of the sector.
In this context the private sector and the society request more and more for local knowledge about forestry and his interaction with the environment.
This contribution try to demonstrate the importance interconnecting forests, science and people on a comprehensive view in a country like Uruguay with a very young forest culture. The case study is based on the experience of the National Agricultural Research Institute, created 1989 as a public legal person within the non-state private law. The governance, the research projects definitions and the technological transfer methodologies are discussed. A direct assignment of resources and the corresponding response on projects and technological results proves the weight of an early interaction with the stakeholders as well as the communication at different levels of the society. On the basis of two projects, different processes of actions and feedbacks are analyzed.
A public-private research organization seems to be a good arrangement in promote co-innovation thru research work.

forestry, research, Uruguay, innovation

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IUFRO17-1816 **Capacity building to increase wood mobilisation at regional level throughout Europe**

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(1) FCBA, equipe approvisionnement, Champs sur Marne, France; (2) FCBA, Charrey sur Saone, France; (3) Forest Research, Bristol, United Kingdom; (4) Forest Research, Social and Economic Research Group, Roslin, Midlothian, United Kingdom

Abstract: European member States' Forest Policies call for increased wood mobilisation to maintain a resilient and competitive forest-based industry. Although a policy imperative set against a strong market, there are a range of technical and economic constraints, including limited interest from forest owners, acting as barriers against mobilisation. However, innovative technical developments including new silviculture techniques and logging operations, or willingness to reconsider business-as-usual actions of organisations, can provide a relevant context to investigate new practices and strategies.

We describe the methodology used in 14 EU regions with the forest sector community (professionals, non-professionals and institutions) to steer them through a process of innovation, and change through the implementation of collaborative pilot projects. Each pilot project was designed with an experimental approach and linked theory of change to the mobilisation of action to overcome a specific set of barriers. As part of the process, stakeholders' commitment and mutual understanding (social learning) was facilitated within Regional Learning Labs (RLL).

These experimental actions, operating since 2014, delivered new knowledge to participating practitioners and new services to their clients and beneficiaries. Their impact were evaluated within the RLL to assess changes in attitudes and practices of those populations of professional operators and forest owners. The lessons learned establishing the pilot projects provide important insights how such approaches might be applied elsewhere.

Added value for wood mobilisation from this global approach is relevant both for regional pilot project leaders and the forestry and business institutions who often support these public-funded initiatives.

participatory capacity building, wood mobilisation

Poster Exhibition Monday

11 - Progress in tropical forest management: Assuring sustainability, avoiding degradation and assisting

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IUFRO17-1883 **Desiccation tolerance study and fruit maturity stage impact on Opilia amentacea. Roxb. seed germination in Burkina Faso**

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Abstract: Opilia amentacea is a multipurpose plant species but over exploitation of its roots is the main threat to its survival. In Burkina Faso, the species is missing in the extreme north and scarce in the West and South. This study was initiated to investigate the morphological variability of fruits and seeds and the impact of fruit maturity stage on germination and (iii) desiccation tolerance of seeds.
Fruit of three maturity stages harvested in five different localities. Morphological parameters of a randomized sample of 100 yellow fruit (mature stage), and seeds extracted from these fruits were measured. 125 seeds of each source and each maturity stage were used for moisture content and germination tests. The remaining seeds extracted from the yellow fruit were dried at room temperature. Every three days, a sample of seeds 125 seeds was used for moisture content and germination assessement.
The results showed a significant morphological variability for both fruit ($P < 0.05$) and seeds ($P = 0.000$) according to the provenance. For all provenances, the average fruit weight was 2.67 mg ± 1.50 and that of the seed was 1.15 mg ± 0.62. The average diameter and length of the fruit were respectively 14.13 mm ± 1.47 and 20.20 mm ± 2.04 while the seed measure 10.72 mm ± 1.49 diameter and 17.60 mm ± 2.05 length.
For all fruits maturity stages, seeds germinate and the viability increases with fruit ripening. The average initial viabilites were 90.76%, 84.92% and 47.49% respectively for seeds extracted from yellow, green-yellow and green fruits. We concluded that seeds of Opilia amentacaea can be harvested at their green-yellow stage. For all sources, seed viability decrease with drying level and died after 10 days of drying. We deducted that seeds of Opilia amentacaea do not tolerate drying. However, investigations should be deepened.

germination, maturity stage, desiccation

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IUFRO17-3626 **Overturn of tegumentary dormency of seeds for the forest restoration in Brazilian savanna**

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(1) National Water Agency, Brasilia, Brazil; (2) Brazilian Forest Service, Brasilia, Brazil

Abstract: The Brazilian savanna is among the biomes with the highest floristic diversity on the planet. However, 48% of the native area was removed or altered due to land occupation for agriculture and urbanization. Therefore, there is demand for recovery of the biome. The jatob á (Hymenaea courbaril), the mutamba (Guazuma ulmifolia) and the canzileiro (Platypodium elegans) are species used in the restoration, through the planting of seedlings. However, the seeds of these species show integument dormancy necessitating the application of treatments to break dormancy. Different treatments were evaluated aiming at the acceleration, the uniformization of the germination and the increase of the germination rates. Pre-germination treatments were used: mechanical scarification with subsequent soaking in water for 48h and imbibition in hot water (100ºC). For each species, the Emergency Speed Index (ESI) and the percentage of accumulated germination were calculated. In both cases, the logistic model was successfully adjusted. Furthermore, the Kaplan-Meier survival analysis was employed. The seeds submitted to treatment obtained higher percentage of germination, higher ESI and higher levels of survival, when compared to the control. The relation between the accumulated precipitation and the germination rate was also analyzed, showing that there was a good correlation between these variables.

forest restoration, seed dormency, savanna

Poster Exhibition Monday

17 - Integrating grassroots participation, crowd mobilization and big data analysis in forest restoration

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2285 **Contribution of community based forest resources management to forest conservation and sustainable resource utilisation in Chimanimani district, Zimbabwe.**

Mujuru, L.* (1); Pambuka, K. (1); Jimu, L. (1)

(1) Bindura University, Dept of Environmental Science, Bindura, Zimbabwe

Abstract: Community based forestry resources management (CBFRM) is a strategy to minimise the problem of environmental degradation in open access resources. The aim of the study was to identify the effects of CBNRM strategies on the forest resource base, identify forest products obtained and associated vegetation cover change over 13 years in Chimanimani district, Zimbabwe. Land cover change was assessed and vegetation was categorised into cleared land, sparse vegetation, grass land and dense forest. Data on utilisation of forest resources was collected from surveys in six selected villages in Chikukwa ward where respondents and key informants were randomly selected. Results showed that the community harvested fruits, edible insects, thatch grass, trees, fiber, animals, soil, stones and honey from the forest. Community participation in CBFRM restored the forest ecosystem through planting trees, sustainable harvesting of the forest resources and reducing veld fires. During the period 1992 -2015, vegetation cover increased whilst land clearing reduced and vegetation was dominated by grasslands and dense forest. Vegetation cover change from 1992 to 2005 was 20.04%, 21.08%, 23.01% and 25.02% for cleared land, sparse vegetation, grass land and dense forest respectively. By 2015,land under sparse vegetation, grass land and dense forest increased by 22.04%, 25.09% and 31.05% respectively relative to 2005. Potential threats to sustainability include overexploitation of resources, unsustainable farming methods, overgrazing and veld fires which can contribute to deforestation and land degradation. There is need for total support from all community members and prevention of veld fires because they can hinder the success of community based forestry resources management in smallholder farming systems. Communities with CBNRM projects have potential for successful implementation of mechanisms such as reduced emissions from deforestation and forest degradation (REDD+).

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IUFRO17-2608 **Comparative assessment of first generation restoration activities in Latin America to support sub-national restoration efforts for generating emissions reductions**

Romijn, E.* (1); Coppus, R. (2); Herold, M. (1); Verchot, L. (2)

(1) Wageningen University, Wageningen, Netherlands; (2) CIAT, Cali, Colombia

Abstract: Land degradation is a serious global problem, with economic consequences as demands for food, feed, fuel, and ecosystem services increase. Restoration of degraded lands is an important component of climate change mitigation and adaptation schemes, poverty reduction efforts, and ensuring food security. The 20x20 initiative aims to bring 20 million hectares of land in Latin America and the Caribbean into restoration by 2020. The purpose of this research is to identify institutional and technical arrangements that lead to successful implementation of restoration activities and to improve understanding of what works and what does not in restoration. We start by mapping and producing a database of restoration activities from the 20x20 initiative and characterize these by populating the database with detailed information on the approaches taken by the different activities. Subsequently we overlay the location of the activities on maps of land degradation, deforestation, biomass, emission factors, and emissions hotspots to analyse the potential for environmental impact of the activities. The analysis will enable us to understand how projects are addressing the underlying drivers of land degradation and if they are likely to have longer-term impacts. We will give recommendations on how restoration can contribute to UNFCCC objectives and SDG goals.

degradation, restoration, emissions reductions

Poster Exhibition Thursday

151 - History, Findings, and Future Directions of Forest Landowner Research

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IUFRO17-3107 **Forest governance on the environmetal protect area of Guaratuba**

Hoeflich, V. A.* (1); Fernandes, A. P. (1); de Souza, M. F. (2); Silva, I. (1); Costa, F. (1)

(1) Universidade Federal do Paraná, Curitiba - Paraná, Brazil; (2) Rodrigues de Souza Sociedades Individual de Advocacia, Curitiba, Brazil

Abstract: Forests, their products and services are key to the well-being of society. In Brazil, the Atlantic Forest has reduced its extension over the centuries due to the predatory extraction, the transforming action of the forest into agricultural land and real estate speculation. The area is a rich region, surrounding by millions of inhabitants, many of which depend on the non timber forest products extraction. Thereby, where people have strong and conflicting objectives for forest use, generally good management depends on good governance. Thus, in this main goal of this presentation is to identify the level of awareness of the principles of good forest governance and propose actions to support public policy directed to the use and conservation of NTFPs. As a methodological procedure the SERVQUAL method, with three sections, each one corresponding to one of the three sections, each corresponding to one of the forest governance pillars proposed by FAO and PROFOR allowed the comparison, as a whole, as the perceptions of various groups of actors (public sector, private sector, international cooperation, academic and non-governmental organizations). And the reliability of the data was confirmed by Cronbach's alpha.

rural communities; forest governance; SERVQUAL

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IUFRO17-2287 **Differences in forest management approaches between common forest and non-common forest in Japan**

Matsushita, K.* (1); Takahashi, T. (2); Yoshida, Y. (1); Senda, T. (3)

(1) Kyoto University, Graduate School of Agriculture, Kyoto, Japan; (2) The University of Shiga Prefecture, School of Environmental Science, Hikone, Japan; (3) Kyoto University, Academic Center for Computing and Media Studies, Kyoto, Japan

Abstract: Privately owned forestlands in Japan may be owned by individuals (5.7 million ha) or by management groups such as corporations (6.4 million ha) (2000 World Census of Agriculture and Forestry). Forestlands owned by management groups include common forest and non-common forest, the proportions of each being determined by the type of management group. Common forest comprises almost 100% of village forest holdings, but almost 0% of corporate forest holdings. Other types of management groups, such as shrines and temples, associations, cooperatives and property wards, hold both common forest and non-common forest. It has been pointed out that the importance of most common forest has decreased greatly, mainly due to the end of fuelwood consumption with the energy revolution, the condition of the current domestic timber market, depopulation of mountainous areas, and aging of forest owners and forestry-related persons. However, these factors seem to be almost the same for non-common forest. We analyzed differences in forest management practices between common forest and non-common forest holdings, using data from the 2000 World Census of Agriculture and Forestry, as part of a research project at the Statistical Digital Archives of Agriculture, Forestry, and Fisheries of the Graduate School of Agriculture, Kyoto University.

common forest, registered name, holding area

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2230 **Reaching Small Forest Landowners in the 21st Century**

Zobrist, K.* (1)

(1) Washington State University, Forestry Extension, Everett, United States

Abstract: Extension education and outreach programs for small forest landowners face a perennial challenge of getting landowners to participate. Even now in the 21st century, when Extension personnel have access to more communication tools than ever (with a variety of online tools that can reach a broad audience at little or no cost), engaging the unengaged and getting landowners to participate in education programs remain a challenge. We conducted landowner surveys in northwest Washington State, USA, to better understand the barriers to participation in Extension education programs and resources and what methods work best for building awareness. We found that the biggest barrier to participation was not a lack of awareness, but simply incompatible schedules due to landowners having so many other demands on their time. Location and content of interest were only moderate barriers, and cost of participation was a low barrier. We found that email newsletters (especially ones with very simple formatting) and websites were heavily utilized, and that these tools by themselves can generate knowledge change, behavior change, and impacts. We found that traditional postal mailings are largely ineffective at getting landowners' attention, and that reaching landowners who are not on our electronic mailing lists or visitors to our websites remains very difficult.

Extension, education, small-scale forestry

Poster Exhibition Thursday

114 - Transforming low grade logs and residues into higher value products through improved supply chain

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IUFRO17-42 **Towards a new model for locating terminals optimally in reference to the resource base and infrastructure**

Athanassiadis, D.* (1)

(1) Swedish University of Agricultural Sciences, Forest Biomaterials and Technology, Umeå, Sweden

Abstract: Terminals for storage and refining of forest biomass are needed to ensure the availability of biomass during periods of high demand or low access to the forest. Where terminals are located plays a central role into whether the terminals are cost-efficient and fully utilized. A novel methodology to select optimal locations of terminals will be presented. The methodology is based on available volumes of forest biomass in the adjacent area, location of woody biomass consuming facilities, forest land ownership, terminal ownership as well as procurement and terminal costs. The poster addresses also the question of making a terminal available to other forest biomass producers as well as the issue of forest biomass swapping between forest companies. The results are specific to the region of northern Sweden but the methodology can be applied at a wide scale.

Terminal location, biomass

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IUFRO17-1844 **Comparison of centralized and decentralized mobile pellet plant production systems for logging residues in Northern Sweden**

De La Fuente, T.* (1); Bergstrom, D. (1); González-García, S. (2); Larsson, S. (1)

(1) SLU, Umeå, Sweden; (2) University of Santiago de Compostela, Santiago de Compostela, Spain

Abstract: A transition to a bioeconomy in EU calls for sustainable, cost- and energy efficient supply of high quality products for replacement of fossil based systems. In many rural areas there is great resources currently produced in a sustainable manner but their usability is highly limited by long transportation distances of raw materials to industries. Thus there is a need of developing systems were such biomaterials are refined closer to the raw material source meaning that the value of materials increases earlier in the value chain which in turn leads to possibilities of economical utilization. Currently development efforts of mobile systems for pelletizing of agro- and forest-based residual biomasses are taken. In order to manage such production systems it is necessary to investigate how such systems should be designed and managed for high energy efficiency, low environmental impacts and cost.

The objective was to quantify and compare cost, energy consumption and environmental impacts related to the production of pellets from logging residues in Northern Sweden through centralized and decentralized mobile systems. The project is ongoing and we will present the results at the IUFRO conference.

bioenergy, biofuels, management systems

Poster Exhibition Thursday

181 - Cross-boundary modelling in a changing world

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IUFRO17-3156 **Hardwood crop tree release: modeling a spatially heterogeneous treatment with a non spatially explicit tree list model**

Béland, M.* (1); Soucy, M. (1)

(1) Université de Moncton, campus d'Edmundston, Edmundston, N.-B., Canada

Abstract: Harvesting practices in hardwood stands of eastern Canada generate thousands of hectares dominated by non-commercial and low-value species with a low stocking of desired species. Releasing just the minimum number of crop trees to capture the stand's growing space at maturity, leaving non-interfering trees, may constitute a low-cost opportunity to restore the vocation of these stands for the production of desired species while maintaining non crop trees for other management objectives. Modeling the outcomes of crop tree release requires some acknowledgement of the heterogeneity of the release. This is not readily possible with commonly used growth and yield models which model average stand conditions. We present an approach to acknowledge this heterogeneity where amendments to growth rates are made for trees growing in a non-spatially-explicit tree list model, based on documented growth rates in different conditions. The approach was applied to three case study stands at the sapling stage from New Brunswick, Canada. Simulation results in terms of merchantable volume by species and size structures are presented for the adjusted approach and compared to that of the unadjusted approach. The extent of the differences between the two approaches highlights the importance of adapting how current models are used, or the relevance of non spatially explicit models, if heterogeneous treatments become more common.

thinning; hardwood; crop tree; tree-list model

Poster Exhibition Thursday

4 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3809 **Can the 3PG model be used to predict the impact of fertilizer applications?**

Tomé, M.* (1); Soares, P. (1); Barreiro, S. (1); Leal, L. (2); Pina, J. P. (3); Oliveira, T. S. (1)

(1) Instituto Superior de Agronomia, Centro de Estudos Florestais, Lisboa, Portugal; (2) ALTRI Florestal, S.A., Olho Marinho, Portugal; (3) Cistus, Floresta e Ambiente Lda., Óbidos, Portugal

Abstract: The use of process-based models to make growth and yield predictions is gaining relevance over the traditional empirical models. Such models, integrating the main physical, biogeochemical and physiological processes involved on forest growth and development, give a mechanistic description of the interactions between the living plants and their environment and are able to assess the energy balance and the cycling of water, carbon and nutrients within a given ecosystem. The 3PG model, a simple process-based stand model requiring few parameter values and only readily available data as input, has been parameterized for growth simulation of eucalyptus plantations in Portugal and the model's use by the companies is increasing. The 3PG model includes the effect of soil fertility through a subjectively estimated parameter between 0 and 1, the fertility rating (FR). There have been some previous works trying to model the FR as a function of soil characteristics but these studies have shown that this prediction is difficult. This presentation explores data from several fertilization trials established in Portugal and analyzes the ability of the 3PG model to predict the impact of the fertilization treatments applied. The analysis is not straightforward as there are many factors influencing eucalyptus growth (the species is highly sensitive to environment variability) and the small size of the plots in the fertilization trial, overemphasizing the impact of tree mortality, are an additional factor that has to be taken into account. Based on the analysis of several trials, this study proposes some practical applications in which the 3PG model can support the decisions of forest managers.

3PG model, fertility rating, fertilization trials

Poster Exhibition Thursday

14 - Strategies and challenges for risk resilient forest management

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2654 **Economic and environmental challenges of climate change for forests of Eastern European part of Middle Latitude zone**

Lakyda, P.* (1); Karpuk, A. (1); Lakyda, I. (1)

(1) NULES of Ukraine, Kyiv, Ukraine

Abstract: Impact of global climate change on forests of northern and equatorial parts of the globe is a subject of long-term systematic research, including environmental and economic forecasts. Eastern European part of Middle Latitude zone, which includes forests of flat part of Ukraine is one of the most potentially vulnerable regions. Given low percentage of forest cover, climate change will actively reflect on habitat trends of the main forest forming tree species (Scots pine, European spruce, Pedunculate oak). These phenomena will be accompanied by dramatic environmental consequences - local forest dieback over large areas. The main reasons for this are weakening of forests by adverse impact of extreme weather events (droughts, windthrows, snowbreaks etc.), infestations of diseases and pests, and catastrophic forest fires. Negative economic effect will be expressed by loss of resources, loss of income and expenditures for implementation of environment stabilizing measures.
All this encourages Ukrainian researchers to conduct consolidated research with European (EFI) and international (IIASA, IUFRO) scientific institutions on development of a system of dynamic models of growth of main forest forming tree species of Ukraine with account of trends of environmental effects of global climate change and economic forecasts which should be taken into account for implementation of risk resilient forest management.
Experimental and modelling groundwork of scientific team of the National University of Life and Environmental Sciences of Ukraine in addressing the outlined challenges give reasons for optimistic expectations regarding implementation of roadmap of sustainable forest management in the region.

Risk resilient forest management Ukraine research

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IUFRO17-4082 **Economic viability of the national forestation program in the Republic of Korea**

Lee, J.* (1); Son, Y. (1); Lim, C.-H. (1); Kim, G. S. (1); Chowdhury, S. (2); Markandya, A. (3); Lee, W.-K. (1)

(1) Korea University, Seoul, Korea, Republic of (South Korea); (2) UNDP Seoul Policy Centre, Seoul, Korea, Republic of (South Korea); (3) Basque Centre for Climate Change (BC3), Leioa, Spain

Abstract: Forest ecosystems provide various ecosystem services, however, the economic viability of forestation program at national scale is still not investigated. The Republic of Korea (ROK) has a successful national scale forestation program and investigation on economic viability of the forestation program can be instructive. In this study, we separately quantified the benefit of ecosystem services (including disaster risk reduction (DRR), carbon sink, water yield enhancement and soil erosion reduction) and the cost of the national forestation program in the ROK. The benefit of DRR was estimated by compiling statistical data of monetary damage and quantifying decreases in the damage with time. Those of carbon sink, water yield enhancement and soil erosion reduction were quantified by modelling approaches. Meanwhile, the cost of the forestation program was estimated by compiling statistical data. Those benefit and cost were converted into the net present value in 2010 by interest and exchange rates. The benefit-cost ratio (BCR) was less than 1 until 1980s since the initial investment exceeded the benefits from the ecosystem services. The break-even points were observed in 1986-1995 and the BCR finally ranged from 2.66 to 4.38 in 2010. Accordingly, it seems economically viable to invest on forestation in the long-term.

Acknowledgement: This study was supported by Korea Ministry of Environment (2014001310008).

Ecosystem service, Forestation, Economic viability

Poster Exhibition Thursday

185 - Towards robust projections of forests under climate change

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4124 **Modelling site index of alien tree species in Poland based on biogeoclimatic data**

Bijak, S.* (1); Bronisz, K. (1); Zasada, M. (1)

(1) Warsaw University of Life Sciences - SGGW, Faculty of Forestry, Warszawa, Poland

Abstract: Site index (SI) as the measure of site productivity should reflect the impact of various environmental factors on the growth of trees. The objectives of the study covered i) elaboration of site index models for three the most abundant alien tree species in Poland (Douglas fir, black locust and red oak) based on biogeoclimatic data from National Forest Inventory or mapped sources and ii) verification of obtained models based on the field measurements. Investigated biogeoclimatic variables included forest site type, soil type, relief form and exposition as well as mean annual or vegetation period temperature and precipitation. SI models were developed using GADA approach. Verification is based on data collected on at least 50 plots per species in each of pre-defined three regions in Poland, where the abundance of alien tree species is significant, i.e. north, west and south-west part of the country. Obtained results will allow to assess the level of adaptation of analysed species to growth conditions in Poland.

site index, alien species, climate, soil, NFI data

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3480 **Integrating field data and simulations to investigate stand development of East North American temperate forests**

Martin-Benito, D.* (1); Pederson, N. (2); Bigler, C. (1); Bugmann, H. (1)

(1) Forest Ecology, Department of Environmental Systems Science, Zurich, Switzerland; (2) Harvard Forest, Harvard University, Petersham, MA, United States

Abstract: Natural disturbances and forest dynamics are superposed by forest management and land use change to create to create the current dynamics and those in the recent past. Analyzing past disturbances at a wide range of spatiotemporal scales can help improve our understanding of the main drivers of forest dynamics, which in turn will contribute to developing better models to simulate future forest development. We use a combination of dynamic vegetation modeling with dendroecological and field data from forests along a wide range of development stages to explore long- and short-term forest dynamics, biomass trends and species composition in the temperate humid forests of eastern North America. Understanding how forests responded to past climatic variability is essential to project how they may behave under future conditions. Because most of these forests have been managed, we particularly include in our analysis some of the remaining old-growth forests which are key to understanding the breadth of natural forest dynamics with minimal human influence. We also focus on past disturbance events that evidenced synchronous alterations of forest vegetation at regional scale and contrast them with different simulation experiments. In the future, these forests will experience changing climate conditions that may impact their disturbance regimes, resilience and ability to accumulate carbon.

natural disturbance; dynamic vegetation modeling

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1405 **Development of a process-based phenology model for Populus**

Svystun, T.* (1); Jönsson, A. M. (1); Bhalerao, R. P. (2)

(1) Lund University, Lund, Sweden; (2) Swedish University of Agricultural Sciences, Umeå, Sweden

Abstract: In temperate and boreal climates, trees synchronize their vegetative growth and development with seasonality in daylength and temperature. Alternating periods of active growth and growth arrest or dormancy are observed in meristematic tissues in trees throughout a year. However, current understanding of the molecular mechanisms controlling the annual growth-dormancy cycle in trees, i.e. phenology, is rather limited. An extensive experimental work towards elucidating the developmental cycle at a molecular level in *Populus* trees has recently started. The experimental work can be complemented by modelling work through analysing and quantifying relations between phenological events and environmental parameters. Therefore, the aim of the current study is to develop a new phenological model relying on mechanistic understanding of light and temperature regulation of tree phenology.
Prior to the construction of a numerical model, information from the relevant scientific literature has been reviewed and summarized as a conceptual map. Additionally, phenological and temperature data have been collected from multiple sources, following by the data analysis. Comparison of interannual variations in temperature with interannual variations in phenology data indicates the effect of temperature on the timing of growth cessation and bud set. Results from the data analysis together with the conceptual framework will provide the basis for model development. Moreover, the model will be driven by climate model data to produce climate change impact assessments, including potential changes in the timing of phenological events.

Tree phenology, daylength, temperature, model

Poster Exhibition Thursday

185 - Towards robust projections of forests under climate change

KG II - HS 2121 (Uni Freiburg)

IUFRO17-732 **Vulnerability assessment of the main forest tree species due to climate change in Ukraine**

Buksha, I. (1); Bondaruk, M. (1); Tselishev, O. (1); Buksha, M. (1); Pyvovar, T.* (1); Pasternak, V. (1)

(1) Ukrainian Research Institute of Forestry, Kharkiv, Ukraine

Abstract: The predictive estimate of climate scenarios dynamics influence on the main forest forming species of Ukraine (Quercus robur, Pinus sylvestris, Betula pendula, Alnus glutinosa, Fagus sylvatica, Picea abies) was done for the separate climate factors as: continentality index by Ivanov, humidity index by Ivanov, and crioclimate (average temperature of the coldest month of the year). Assessment was conducted by individual climatic factors on the basis of scales of ecological amplitudes of native species of Ukraine. The calculated coefficient of satisfactory of environmental conditions for flora varies from 100% in the center of the ecological amplitude of species tolerance to 0 at its limits.
By GIS methods for several climatic scenarios (for climatological standard period (1961-1990), present climate (1991-2010) and forecasted periods (2011 -2030, 2031-2050, 2081-2100)), the simulation of areas with satisfactory of environmental condition by climatic factors described above was carried out for each of forest tree species.
By the end of this century it is expected appearance of large areas with climatic conditions unfavorable for the growth of the studied tree species and the likelihood of changes in zonal vegetation types. The slightest change in areas favorable for growth and development of forests are forecasted for Quercus robur and Alnus glutinosa, and the largest - for Picea abies and Fagus sylvatica. The main limiting climatic factor is humidity of climate. At the areas of unfavorable climatic conditions it is forecasted a significant decrease in productivity of forest forming species, gradual loss of their reproductive capacity and the possibility of natural regeneration, reducing of resistance to pests and diseases and increasing the threat of forest fires.

vulnerability, climate change, forest, Ukraine

Poster Exhibition Thursday

155 - Cities, Trees, Carbon, and Climate Change Mitigation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-322 **A comparison of two urban forest assessment techniques in Minneapolis, Minnesota, USA**

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(1) Royal Forest Department, (International Forest Cooperation Office), Bangkok, Thailand; (2) College of Natural Resources, University of Wisconsin-Stevens Point, Stevens Point, Wisconsin, United States

Abstract: This study was done to compare the performance of different urban forest sampling methods. The first approach used 1/5 acre circular plots that were randomly located and potentially traversed several properties requiring permission from all owners to collect data for the plot. The second approach used randomly selected lots (requiring permission from only one landowner) as the sampling design and large park areas assessed with randomly located circular plots. The urban forest assessment results from i-Tree Eco were used to compare the urban forest in Minneapolis MN, USA using data from Nowak et al, 2006 (approach one) and Hanson, 2009 (approach two). The results of two different urban forest assessment approaches were similar for urban forest structure. The study found the total number of trees was ±1.6% of each approach, trees per capita was ±1.7% different, and tree density was similar among approaches. Tree age distribution in both studies showed a same trend (revise J-shape). Urban forest function results were lower for the random lot approach due to the street-tree right-of-way not being sampled. Inclusion of a street tree study combined with the random lot approach yielded results similar to the Nowak et al. 2006 circular plot design. The significance of this study could guide the decision maker for future urban forest sampling techniques to be design in appropriate to its specific objectives.

Comparison; i-Tree Eco; Sampling; Urban Forest, MN

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2818 **The potential of imaging from ultra-light aircraft for urban tree inventories: case study in Kaunas, Lithuania**

Mozgeris, G.* (1); Gadal, S. (2); Jonikavicius, D. (1); Straigyte, L. (1); Ouerghemmi, W. (2); Juodkiene, V. (1)

(1) Aleksandras Stulginskis University, Akademija, Kaunas region, Lithuania; (2) Aix-Marseille Université, CNRS ESPACE UMR 7300, Aix en Provence cedex 4, France

Abstract: The presentation is aimed to introduce imaging system based on simultaneous use of frame-type Rikola hyperspectral and RGB/CIR cameras applied for inventories and monitoring of urban green spaces. The system is run from a manned ultra-light aircraft, equipped for aerial photography missions. An aerial imaging campaign over the city of Kaunas, Lithuania was carried-out in summer of 2015 and 2016, acquiring narrow-bands measurements in the 500-900 nm spectral domain at 16 and 60 bands respectively, with a full width at half maximum ~10 nm. Simultaneously, aerial images were shot using Nikon D800E camera, converted and reconfigured to capture in NIR, Red+NIR and Green+NIR bands. Several methodological solutions for image calibration, co-registering of separate image bands, atmospheric correction and photogrammetric processing are investigated. Information available from the inventory of green spaces in Kaunas city was used to guide the selection of trees for identification studies and validation. Six urban deciduous tree species were separated using tree crown level statistics, extracted from 16 visible-near infrared spectral bands hyperspectral images, and discriminant analyses with an overall classification accuracy of 63.1 %. Fusion of hyperspectral and color-infrared images increased the classification accuracy by 3%. The identification accuracy of three tree health condition classes ranged from poor to moderate. The influence of increased number of hyperspectral bands on tree species ability as well as more advanced image processing solutions will be tested using materials from year 2016 campaign. The presentation will also discuss the potential of combining images from different platforms, ranging from unmanned aerial vehicles to space satellite systems, including the technological and economic reasoning.

hyperspectral imaging, tree species identification

Poster Exhibition Thursday

30 - Managing recreation: Empirical insights and forest management instruments.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2785 **Latent Preferences of Tourists towards the Service Quality of the Taichung Calligraphy Greenway, Taiwan**

Chung, C.* (1); Liu, W. (1)

(1) Dept of Forestry, National ChungHsing University, Taichung, Taiwan

Abstract: This study used the choice experiment method to evaluate visitors' preference levels for five major attributes of Calligraphy Greenway, which can be used to improve the current recreational quality of Calligraphy Greenway. The main analyzed results are summarized as follows. On average, each tourist visited Calligraphy Greenway 9.15 times in the past year, and spent 2.37 hours there for each time. Among the five recreational attributes, satisfaction with opportunities for recreational activities is the highest, whereas that with human landscape resources is the lowest. The ordering of the importance of the five attributes from highest to lowest is quality of recreational service facilities, total recreational cost, natural landscape resources, human landscape resources, and opportunities for recreational activities. From analyzing the effects due to various levels of each attribute, the higher the total recreational cost is, the lower the utility of tourists is; and, the higher the quality of recreational service facilities is, the higher the utility of tourists is. From the results of opportunities for recreational activities, tourists had a higher utility for ornamental recreational activities. Both natural landscape resources and human landscape resources show positive benefits for tourists. For comparing difference between groups, female tourists were more concerned about the recreational total cost and the opportunities for recreational activities; whereas male tourists were more concerned about the quality of recreational service facilities, natural and human landscape resources. Local tourists were more concerned about the total recreational cost and the opportunities for recreational activities; whereas foreign tourists were more concerned about natural and cultural landscape resources, while both were concerned about the quality of recreational service facilities.

Service Quality,Latent Preferences,Leisure Benefit

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2992 **Assessing recreation and societal demands in urban proximate woodlands using the concept of Ecosystem Services**

Lupp, G.* (1); Förster, B. (1); Kantelberg, V. (2); Honert, C. (1); Naumann, J. (1); Markmann, T. (1); Koch, M. (2); Pauleit, S. (1)

(1) Technical University of Munich, Chair for Strategic Landscape Planning and Management, Freising, Germany; (2) Bavarian State Institute of Forestry, Freising, Germany

Abstract: The concept of Ecosystem Services (ES) can serve as an eye-opening metaphor for managers, stakeholders and decision makers. The concept comprises both the provisioning and societal demand for ES. Using the concept and ultimately putting monetary values to ES, it can contribute to a better understanding of goods and services provided by forests and support multifunctional forest management strategies providing also numerous non-market goods and services that are important for the society.
Although laypersons perceive regulating ES as most important in urban proximate woodlands, recreation is considered one of the most important ES in urban woodlands and can put severe pressure on other ES. While data on many provisioning and regulating services is available and can be modeled, often only very general assumptions are used for forest recreation. Therefore on-site data is necessary to better understand and evaluate the demand for outdoor recreation opportunities in urban woodlands and its societal value.
Finally, visitor management concepts depend on this data to be able to serve as a tool to safeguard biodiversity and ability of forests to provide ES. Using forests in the Munich Metropolitan Area, we demonstrate methods assessing recreational demand by collecting data from quantitative and qualitative interviews and using camera traps for visitor counting. We could demonstrate that each forest and recreational activity have specific daily and seasonal as well as distinct spatial patterns. Therefore only some rough general assumptions can be made from these studies. For two forests in Freising in the north of the Munich Metropolitan Region, we could calculate a recreation value up to 15440 Euro per year and hectare.

Recreation, Ecosystem Services, Societal Demands

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3287 **Visitor monitoring using trigger camera traps - An study at the Grünten Mountain in Bavara**

Naumann, J. (1); Lupp, G.* (1); Förster, B. (1); Honert, C. (1); Kantelberg, V. (2); Koch, M. (2); Pauleit, S. (1)

(1) Technical University of Munich, Chair for Strategic Landscape Planning and Management, Freising, Germany; (2) Bavarian State Institute of Forestry, Freising, Germany

Abstract: The evaluation of visitor management actions is dependent on profound data about visitor flows and visitor numbers. Often more qualitative data is necessary to provide information on recreational activities to provide adequate visitor management concepts and its evaluation.

The Grünten Mountain is situated in the southernmost part of Bavaria and hosts a unique alpine flora and fauna. Forests play also a vital part to stabilize the slopes to prevent rock falls, erosion or severe floods. To maintain biodiversity and safeguard the development of resilient forests, a number of protected areas and forest recovery areas were established in the past years. Also a visitor management concept was implemented. It consists of protected areas, quiet zones for wildlife and codes of conducts for visitors. Using camera traps, visitor numbers and recreational uses were assessed. It was also analyzed, if the information board of the visitor management campaign was noticed.

Quite large visitor numbers up to 400 passing persons per day were recorded during the study. Significant night uses (mainly with headlamps) could be detected. Up to 19 dogs per day were recorded, most of them off-leash. While around 56% of the children took a closer look at the information board, only one third of the passing adults noticed the sign. While some stakeholders complained about "huge" numbers of Mountain Bikers causing disturbance of wildlife, it could be shown that only very few bikers used the trails during the study.

Camera traps provide valuable data for visitor management. However, intense communication and PR work is necessary to gain acceptance for this type of visitor monitoring.

Camera Traps, Visitor Management

Poster Exhibition Thursday

30 - Managing recreation: Empirical insights and forest management instruments.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2137 **GIS based socio-ecological tools to promote the multiple use of forests**

Kangas, K. (1); Tolvanen, A. (1); Tarvainen, O.* (1); Nikula, A. (2); Nivala, V. (2); Huhta, E. (2); Tuulentie, S. (2); Hytönen, M. (3); Jäkäläniemi, A. (4); Tyrväinen, L. (3); Kyttä, M. (5)

(1) Natural Resources Institute Finland (Luke), Oulun yliopisto, Finland; (2) Natural Resources Institute Finland (Luke), Rovaniemi, Finland; (3) Natural Resources Institute Finland (Luke), Helsinki, Finland; (4) University of Oulu, University of Oulu, Finland; (5) Aalto University, Aalto, Finland

Abstract: The multiple use of forest ecosystems require simultaneous consideration of socioeconomic and ecological values. In this study we developed a mapping method in order to estimate the importance and potential for recreation and tourism development. The increase in recreation and tourism is often related to the development of protected areas and holiday resorts. Nevertheless, recreation and tourism are considered one of the major threats to wilderness ecosystems and threatened species.

The importance and potential for recreation and tourism development of sites were estimated using information from Public Participation GIS (PPGIS) survey and classification of ecological values in the research area. Four criteria associated with the user hotspots were used for the new scoring of each spot (1 ha grid square): 1) recreational activities, 2) pleasant site, 3) ecological values, and 4) cultural values. Spots marked by respondents as being used for activities or as pleasant sites were regarded as suitable sites for the recreation and tourism development. This new scoring was visualized by mapping the result. Also, the relationships between user hotspots, cultural and ecological features were investigated.

Our method provides tools to reconcile both socioeconomic and ecological values to fulfil the requirements of sustainable planning and decision-making.

PPGIS, recreation, sustainability, tourism

KG II - HS 2121 (Uni Freiburg)

IUFRO17-723 **Managing recreation - an overview of guidelines for recreation in municipal forests. A case study of Poznan (Poland).**

Wajchman-Switalska, S.* (1); Jaszczak, R. (1)

(1) Poznan University of Life Sciences, Poznan, Poland

Abstract: Poznan is one of the most important urban centers in the country. The city area is 261.9 km sq., the share of built-up areas amounts to 44%, while 48% are agricultural areas, woodlands and greenery. Most of the urban lands are the property of municipal units or private landowners (by 36%).
The area of municipal forests amounts to 2576 ha and they are divided into 4 municipal forest districts: Zieliniec, Antoninek, Marcelin and Strzeszynek. The governance of the municipal forests is assigned to the Poznan City Forest Enterprise which is a budget, self-government venture.
Regulations relating to forest management and policy in the municipal forests are a reflection of the expectations of society that urban forests are for residents of the city, primarily a place to satisfy their needs of rest and recreation. The management of these areas is based on the acts on the national and local levels (eg. management plan). In order to improve effectiveness of the management process, "Guidelines regarding the management of communal forests of the City of Poznan" were drawn up.
The authors present frameworks for recreation on the basis of documents strictly dedicated to municipal forests in Poznan and the City Development Strategy which refers also to the green city areas. Selected recommendations ranges from the forest tending, through shaping the edges and walls of the forest, to the technical facilities of the forest for recreation.

recreation, municipal forests, forest management

Poster Exhibition Thursday

133 - Social dimension of wildlife conservation and management

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1978 **Meat consumption, interaction with hunters and attitude toward hunting. Is there a universal relationship?**

Krokowska-Paluszak, M.* (1); Lukowski, A. (2); Wierzbicka, A. (1); Skorupski, M. (1); Sagan, J. (3); Gruchala, A. (4); Tomusiak, R. (4)

(1) Faculty of Forestry, Poznan University of Life Sciences, Poznan, Poland; (2) Faculty of Forestry, Poznan University of Life Sciences, Institute of Dendrology, Poznan, Poland; (3) Regional Directorate of State Forests in Warsaw, Warszawa, Poland; (4) Faculty of Forestry, Warsaw University of Life Science, Warszawa, Poland

Abstract: In recent years hunters in Poland are having a very low level of social acceptance. People do not know or forget that thanks to the economy of hunting, we are able to control the populations of game animals. Both American researchers and scientists from Sweden demonstrated that contact with hunters is one of the decisive factors affecting the social acceptance of hunting.
The aim of our study was to verify the relationship between the frequency of consumption of venison and acceptance of sustainable hunting in Poland. In addition, in these studies were determined how contact with hunters affects approach to themselves and their activities in the environment.
We hypothesized that:
- the more often people eat venison, the bigger their acceptance for game management.
- more frequent and closer contact with hunters makes a positive assessment of hunting.
- people from rural area have higher acceptance and understanding for basics of sustainable hunting than from urban areas.
During the study we used the survey as a research tool on a randomly selected representative sample of at least 1,000 respondents. Respondents were asked about age, gender, level of education, place of residence and whether they are hunters, as well as whether they ever had contact with hunters. Respondents had to answer for example whether: they thought that hunting helps support the balance of nature?; hunters are adequately trained to perform hunting?; they accept the game management?; they consume venison and recognize the health benefits and taste of wild meat?; and how they evaluate the availability of venison on their domestic market?
The obtained results will be presented during Conference and compared with similar research in Europe and data in literature. Results will allow to take measurable steps towards increasing social acceptance of hunting, and also can be used as a strong argument in the discussion about the existence of sustainable hunting.

game management, society, game meat

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3916 **Consequences of the moratorium on moose hunts (Alces alces L.) in Poland**

Sagan, J. (1); Balik, B. (2); Wawrzyniak, P. (3); Krokowska-Paluszak, M.* (4); Tomusiak, R. (5); Skorupski, M. (4); Blasiak, A. (4)

(1) Regional Directorate of SF in Warsaw, Warszawa, Poland; (2) Directorate-General of the State Forests, Warszawa, Poland; (3) Regional Directorate of SF in Bialystok, Bialystok, Poland; (4) Department of Game Management and Forest Protection, Faculty of Forestry, Poznan, Poland; (5) Laboratory of Dendrometry and Forest Productivity, Faculty of Forestry, Warszawa, Poland

Abstract: Size of moose population in Poland was constantly changing in past decades. Reconstruction of its structure was started in the 50s. In 1967 moose hunting was resumed. Moose population was strongly growing in 70s - 80s, when reached the number of 6200 individuals. Increasing size of moose population caused damages, so hunting acquisition was intensified, what in turn resulted in drastic decline in population size. In On the beginning of XXI century, Polish moose population was on the level of 2000 individuals. In 2001 the moratorium on moose hunting was introduced with the status of "game species with all-year protection period". The assumption was, that this moratorium should remain until the moose population in Poland will be reconstructed, what will ensure the stability of this species. Now, the moose population in Poland counts about 30k individuals and is steadily increasing. Currently, it is estimated, that losses incurred by State Forest and agricultural and orchard management, because of moose damages, measures about 55 million zl per year. Social debate about moose species population management is still ongoing in Poland, but because of divergent opinions, its seems impossible to achieve an compromise. Meanwhile, the moose population is not managed in any way.

hunting, protection, moratorium, moose, damages

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3373 **The community forestry enterprise in the Monarca butterfly region in Mexico: an approach with enterprise vision**

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(1) Colegio de Postgraduados, Montecillo, Texcoco, Mexico

Abstract: In the community forest enterprises (CFE) of the Monarch Butterfly Biosphere Reserve (RBMM) there is not an interconnection in the forest production process. For thus, an integration is needed that has a positive impact on the natural resources, the Monarch Butterfly habitat (MMH) and the forest community. The objective of this research was to analyze the corporate principles of the CFE in the integration of the forest production chain (IFPC) and in the conservation of natural resources. Using a structured and semi-structured survey, spatial analysis on a digital platform, design and construction of development indices through multivariate methods, we compared three case studies with different levels of IFPC. The results indicate that as the CFE integrates more links into the production chain, the members have a better knowledge of the objectives of the CFE, better aspirations and an improvement in the culture of the forest management and conservation. Also in the conservation of their forests and economic benefits and social welfare for the community. For the conservation of the MMH, the Reserve administrators must promote the ICPF through the consent and opinion of the forest community.

strategic analysis, community, conservation.

Poster Exhibition Thursday

133 - Social dimension of wildlife conservation and management

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3995 **Osteometric characteristic of jawbones of living in urban-industrial agglomeration range in central Greater Poland wild boars (Sus scrofa L., 1758)**

Gorecki, G. (1); Bienias, M. (1); Kamieniarz, R. (1); Skubis, J. (1); Skorupski, M.* (1)

(1) Department of Game Management and Forest Protection, Faculty of Forestry, Poznan, Poland

Abstract: Study material was collected in Zielonka Game Management Centre - property of Poznan University of Life Sciences. The Zielonka GMC has an area of 12,3k hectares and is placed 25 km north east form Poznan. The main part of this area is dense forest complex "Puszcza Zielonka" with surface of 9k hectares. Due to the fact, that this is the nearest to Poznan forest complex, it is used as a place of recreation for city residents. Domination of west and west-south winds causes flow of polluted air from agglomeration. For this study, 446 jawbones of wild boars, hunted in 2005-2009 (255 squeakers, 160 pigs of sounder and 31 older wild boars) were used. The measurement of 21 parameters on every jawbone was done. Moreover, data collection includes carcass weight and age of every individual. On the basis of descriptive statistics and PCA analysis, 5 studied parameters, most associated with age and sex of individual, were selected. Analysed parameters of squeakers and pigs of sounder jawbones were significantly less diverse than carcass weight. Average variation of jawbone parameters was 12 % for squeakers (29% carcass weight) and 10% for pigs of sounder (19% carcass weight). For older wild boars variation of jawbone parameters and carcass weight was equal (10%).

wild boar, osteometry, game management

Poster Exhibition Thursday

165 - Dothistroma and other needle diseases of pine

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1621 **Distribution and Characterization of Dothistroma Needle Blight Pathogens on Pinus mugo in Slovakia**

Adamcikova, K.* (1); Ondruskova, E. (1); Janosikova, Z. (1)

(1) Institute of Forest Ecology, SAS, Nitra, Slovakia

Abstract: The occurrence and distribution of Dothistroma needle blight (DNB) on Pinus mugo was studied in 2014-2015 around the Slovakia. Totally 42 localities were investigated both native and planted ones. Symptoms of DNB were observed on 35 localities only on planted shrubs. All these 35 localities are new P. mugo DNB stands. No DNB symptoms were observed in natural and naturally regenerated plantations. DNA was extracted from a total of 236 isolates and 8 needle samples. Based on the ITS-rDNA comparisons and using species specific primers the both phytopathogenic Dothistroma species were detected: D. septosporum and D. pini. Isolates of D. septosporum had ITS sequences identical to D. septosporum from Europe and both mating types were identified with slight predominance of MAT2. The ratio of D. septosporum mating types varies significantly between sites, ranging from an equal proportion of each mating type to single mating type populations. D. pini ITS sequence grouped with D. pini from Ukraine, Russia and Switzerland and only MAT2 was found.

Dothistroma, Pinus mugo, Slovakia, mating types

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1419 **Brown Spot Needle Blight (Lecanosticta acicola), a risk for European pine forests - research requirements providing an effective control**

Cech, T. L.* (1)

(1) Federal Forest Research Centre, (BFW), Vienna, Austria

Abstract: Brown-spot needle blight caused by Lecanosticta acicola (LA) is a disease of various pine species likely indigenous to North and Central America. It is persistent on infected individuals and causes decline of trees. Having invaded Europe several decades ago, it affects pines mostly on urban sites. In recent years, records of LA increased in number, especially in Northern European and some Central European countries. Moreover, it has also been found in managed and unmanaged forests attacking Pinus sylvestris, P.mugo, P.nigra and P.halepensis. In Austria, LA was reported in 2015 from P.mugo in the Alps, where the outbreak endangers protection forests.
Facing this increase in number and impact, efficient management strategies are needed especially for the European forest ecosystems. These require detailed knowledge on epidemiology, biology and pathogenicity of the pathogen. Research should focus on key questions on the pathogens' spread in Europe, its biology, its effects on the host in relation to climatic and site conditions and other biotic factors in order to gain knowledge to support contingency planning and impact and risk management. These objectives will be persued in a multinational project within the European EUPHRESCO network during the upcoming years.

Lecanosticta acicola, Europe, research needs

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1649 **Dothistroma pini determined on different host species in Slovakia**

Ondruskova, E.* (1); Adamcikova, K. (1); Janosikova, Z. (1)

(1) Institute of Forest Ecology SAS, Nitra, Slovakia

Abstract: Dothistroma needle blight is one of the most serious disease of Pinus sp. Two distinct species, Dothistroma septosporum and a less frequent D. pini, are considered as causal agents. The occurrence of DNB symptoms was observed on more than 70 localities. DNB were extracted from 70 pure cultures and from 29 needle samples. Based on the ITS-rDNA, Beta tubulin or Elongation factor 1 alpha comparisons and using species specific primers the D. pini species has been detected on 15 localities and in 80 samples. Occasional, in the same sample both Dothistroma septosporum and D. pini were detected. The collection of D. pini samples was analysed for a mating type. Both mating types were determined, most of the isolates were distinguished as MAT 2. Interestingly, 3 samples only from one donor tree showed, that also MAT 1 type is present in Slovakia. D. pini in Slovakia has abundant hosts range, it have been found on 10 Pinus sp. and also on Picea.

Dothistroma pini, hosts, MAT type, Slovakia

Poster Exhibition Thursday

167 - Ecosystems, climate change and hydrology

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3164 **Damage of leafroller insects Tortricidae in young Scots pine stands in Latvia**

Miezite, O.* (1); Ruba, J. (1); Dubrovskis, E. (1); Pilbergs, E. (1)

(1) Latvia University of Agriculture, Jelgava, Latvia

Abstract: Area of Latvia is 6.46 million hectares and 52% of this area is covered by forests. Scots pine (Pinus sylvestris L.) stands occupied in 2015 - 993274 ha or 34% of the total forest area. In Latvia Scots pine is economically valuable tree species. Its economic potential is affected by various abiotic and biotic factors. The global warming effect and climate change affects the factors mutual influence and species occurrence in forest ecosystems. In change context evaluation of Tortricidae family moth influence on young Scots pine stands in Latvia forestry is needed. Data was collected in 7 Scots pine stands from six to ten year old in Cladinoso-callunosa, Vacciniosa and Myrtillosa forest site types of North-West part of Latvia. During research 39 temporary sample plots with radius of 3.99 m and area of 50 m2 were established. The aim of this research was to analyze leafroller insects (Tortricidae family) damage in young Scots pine stands. There is no significant difference between stand density, average tree height, average diameter of tree root collar and damage intensity of moth damaged trees ($p>0.05$). After evaluation ($p>0.05$) concluded that leafroller moth damage is insignificant and does not cause economic losses of forest ecosystem management.

young stand, stand density, diameter.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3169 **Formation dynamics of the organic layer and ground vegetation in the Scots pine plantations with different initial planting density**

Miezite, O.* (1); Ruba, J. (1); Liepa, I. (1)

(1) Latvia University of Agriculture, Jelgava, Latvia

Abstract: Humus, mineral accumulation, soil structure, chemical properties, as well as ongoing biological processes in the soil are depending from the organic layer. The litter and humus have significant impact on forest life, regeneration, growth dynamics and the pace of aging. The aim of this investigation was to analyze the formation of ground vegetation and organic layer in plantations with different initial thickness. Twenty square sampling units were established at the 22 old pine plantations and ground vegetation and litter different fractions were evaluated (collected, sorted, weighted and dried). Field observations were carried out throughout the year during summer, autumn and winter-spring periods. Dry weight of ground vegetation declined with increase of initial planting density. For instance, in the plantation with initial density 3330 trees per ha averaged ground vegetation dry biomass was 156.9 kg ha-1, but with planting density 10000 tree per ha (63.1 kg ha-1) only. Litter accumulation indicated similar trend (the quantity of litter - at 3330 pcs. per ha dry biomass was 3219.1 kg ha-1, at 12500 pcs. - 1897.5 kg ha-1). In different time periods ground vegetation and litter dry weight ware shown significant differences among plantations with varied initial thickness ($p>0.05$).

Pinus sylvestris, litter, vascular plant

Poster Exhibition Thursday

199 - Effects of global change on Mediterranean forest insects and interactions with pathogens

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1054 **Dispersal of three Lepidoptera on Quercus coccifera and its effect in their stability in Tunisia forests**

ezzine, O.* (1); hammami, S. (1); dhahri, S. (1); ben jamaa, M. L. (1)

(1) INRGREF, Ariana, Tunisia

Abstract: Climatic change can have a major effect on many species, both directly by changing their activity, development, phenology and survival as well as indirectly through host phenology and geographical ranges. In spring 2005, larvae of Orgyia trigotephras (Eribidae, Lymantriinae) were observed on Q. coccifera, in Jebel Abderrahmane, but later in spring 2010, they were observed in Sejnane. However, in spring 2012, in addition to O. trigotephras, pupae of Acrobasis consociella (Pyralidae, Phycitinae) were observed on Q. coccifera in Jebel Abderrahmane and in Sejnane. In 2013, in addition to these two pests, Phyllonorycter messaniella (Lepidoptera, Gracillariidae), a leafminer was observed on Q. coccifera. Preliminary investigations of these pests were carried out in two stations, in the north-eastern and the north-western forests. In each station two orthogonal transect lines were opted. Each transect consisted of 12 plots. To estimate host plant infestations', a direct counting was carried out on the host plant (Q. coccifera) during 2005 (first outbreak of O. trigotephras), 2013, 2014 and 2015. In Jebel Abderrahmane, the mean number of egg-masses of O. trigotephras was 7.36 (2005) decline to 0.20 (2013), 0.34 (2014) and 0.8 (2015). In Sejnane, was 0.42 (2013), 0.66 (2014) and 0.16 (2015).
The mean number of shelters of A. consociella were 1.71 (2013), 1.31 (2014) and 3.33 (2015) in Jebel Abderrahmane. It was 21 (2013), 2 (2014) and 0.4 (2015) in Sejnane. Foliage infested by P. messaniella was observed in abundance in Jebel Abderrahmane than in Sejnane, with respectively 0.58 and 0.16 (2014), 2.38 and 0 (2015). It's clear that A. Consociella took the place of O. trigotephras in the two forests and probably P. messaniella will take the place of the two others pests, consequently this distribution may affect the dynamic of each pest.
This work is a preview on competition of three Lepidoptera on Q. coccifera in Tunisia forests.

O. trigotephras, A. consociella, P. messaniella

Poster Exhibition Thursday

5 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2975 **Modeling tree growth and development under mistletoe infestation**

Bilgili, E.* (1); Baysal, I. (2); Coskuner, K. A. (1); Ozturk, M. (1); Usta, Y. (1); Serdar, B. (1); Eroglu, M. (1); Yavuz, H. (1)

(1) Karadeniz Technical University, Faculty of Forestry, Trabzon, Turkey; (2) Duzce University, Faculty of Forestry, Duzce, Turkey

Abstract: European pine mistletoe, Viscum album ssp. austriacum (Wiesb.) Volmann, causes substantial damage to the growth and development of Scots pine (Pinus sylvestris L.) stands. This paper presents a dynamic tree growth model that quantifies the effect of mistletoe on the growth and development of Scots pine. The model is a state and distance dependent tree model. The model simulates diameter, height and crown characteristics. Crown characteristics include; crown length, crown width, crown base height, crown closure and foliage. The model is based on simplified plant growth relationships as regulated by physiological processes, namely photosynthesis and respiration. The bounding of the model considers both temporal and spatial aspects; with a time span of 100 years and iterative steps of one year. The model simulates crown growth of an average tree. Crown growth is modeled by growing one side of the tree crowns into the space between two trees, whorl by whorl. Crown width growth is regulated by the light it receives and the concurrent height increment. Using allometric relationships, crown foliage biomass is calculated. Based on the amount of foliage and the state of the tree characterized by dbh, height and size (volume), photosynthate allocation to different organs are made. Height growth is determined based on the potential height growth increment for the current year. Potential height growth increment is regulated by the ratio of the available foliage biomass to the potential foliage biomass required for potential height growth increment. Current years' height increment is then calculated as a function of potential height growth increment as influenced by the available net production in the previous year. Similar approach was adopted to calculate diameter growth. The effect of mistletoe on the growth and development of trees was based on the amount of mistletoe biomass in relation to foliage and the state of the host tree.

Viscum album, Pinus sylvestris, Growth, Model

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4036 **Unravelling the past to manage Newfoundland's forests for the future**

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Abstract: The forests of Newfoundland represent a unique type of boreal ecosystem with diverse environmental gradients that exercise strong control over disturbances and vegetation. We have assembled and analyzed a comprehensive database on disturbance history in Newfoundland. Defoliating insects, led by the eastern spruce budworm (Choristoneura fumiferana Clemens) and the hemlock looper (Lambdina fiscellaria Guenée), have the largest disturbance footprint on the island. Infrequent wildfires (fire cycle = 769 years) had a decisive role in driving forest succession, particularly in the Central Newfoundland Forest and Maritime Barrens ecoregions. We hypothesize that the historical disturbance regime in Newfoundland would not have enabled steady-state conditions, although the amount of old-growth forests and deadwood would likely have been greater than it is today. We argue that the implementation of the natural range of variation (NRV) concept in forest management for such non-equilibrium systems will be challenging in Newfoundland and in other regions of Canada. We propose guiding principles to adapt the NRV concept using ecological knowledge. If a science-based approach is desired, assumptions about NRV should be tested using a rigorous experimental design. We encourage the establishment of large-scale experiments in at least a portion of forestry operations to enable an ecosystem science-based approach.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1741 **Kauri dieback in New Zealand: ancient trees meet new pathogen, new pathogen meets genomic interrogation.**

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(1) Bio-Protection Research Centre, Institute of Fundamental Sciences, Palmerston North, New Zealand; (2) Bio-Protection Research Centre, Institute of Agriculture and Environment, Palmerston North, New Zealand; (3) Scion, New Zealand Forest Research Institute Ltd, Rotorua, New Zealand; (4) University of Exeter, Exeter, United Kingdom; (5) Sainsbury Laboratory, Norwich, United Kingdom

Abstract: New Zealand Kauri (*Agathis australis*) forests of northern regions of New Zealand are among the most ancient in the world. Kauri can live for well over 2,000 years and iconic giant trees have special cultural significance for indigenous Maori. A lethal epidemic of kauri dieback, caused by the oomycete pathogen *Phytophthora agathidicida*, has recently spread over most of the native New Zealand kauri regions, posing serious threats to this species. As part of a national effort to develop ways to manage this disease, we have taken a genomic approach to study the genetic diversity of the pathogen and how it interacts with its host. We sequenced the genomes of 14 *P. agathidicida* strains, identified potential virulence genes based on similarities with well-characterised genes in other *Phytophthora* pathogens and screened the gene products for virulence functions. The genome sequences suggest the pathogen was introduced to NZ and will help determine which pathogen strain(s) are best to use when screening kauri seedlings for disease resistance. The discovery of genes with virulence functions is expected to provide further tools for resistance screening. This knowledge will help target efforts to conserve these iconic trees.

Kauri dieback, epidemic, Phytophthora, genomics

Poster Exhibition Thursday

5 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1197 **Molecular identification of vegetative compatibility types of Cryphonectria parasitica, a causal agent of chestnut blight**

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(1) University of Zagreb, Faculty of Science, Dept of Biology, Zagreb, Croatia

Abstract: The ascomycete fungus Cryphonectria parasitica (Murr.) Barr, causal agent of chestnut blight, is probably one of the best known invasive fungal pathogens in chestnut forests of Castanea sativa in Europe and C. dentata in North America. In Europe, the most effective known way to combat chestnut blight disease is by means of biological control utilising Cryphonectria hypovirus 1 (CHV1), which reduces virulence and sporulation of infected C. parasitica strains, converting them to hypovirulent ones. However, anastomosis-mediated, horizontal virus transmission between hypovirulent and virulent strains is hampered by vegetative (in)compatibility (vc) system involving at least six known di-allelic vic genetic loci. Traditionally, vic gene profile is determined by pairwise cultivation of isolates with EU tester strains. The goal of this study was to implement PCR-assay for routine characterization of vic genetic structure of European C. parasitica populations. We have combined already known/published and newly designed primers for amplification of six know vic loci known in European C. parasitica populations. The vc genotypes determined by PCR for 155 C. parasitica isolates tested in this study were in complete agreement with the vc genotypes determined by pairwise co-culturing of the same isolates, revealing the specificity and accuracy of the PCR-based molecular vic genotyping assay. We found 26 unique vegetative compatibility (vc) genotypes among 155 isolates, 12 of which were shared between populations and 14 unique in each one, making Croatian C. parasitica populations among the most diverse in Europe regarding the number of vc types and genetic diversity. Unexpectedly, isolates in which both alleles at single vic loci were amplified were found, suggesting the occurrence of heterokaryonic state in these isolates. To conclude, results here validate the specificity and accuracy of the PCR-based molecular vic genotyping assay.

heterokaryon, vegetative incompatibility, vic loci

KG II - HS 2121 (Uni Freiburg)

IUFRO17-441 **A new non-parametric method to detect insect outbreaks from satellite imagery**

Estay, S.* (1); Chavez, R. (2)

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Abstract: Insect outbreaks are considered one of the major disturbances in temperate forests. Most of the current algorithms used today to detect outbreaks from satellite imagery are based on pre-established functions or are constrained to specific probability distributions, which not necessarily are optimal for all forest types, climates or phenological patterns. In this study, we developed a mathematical algorithm based on kernel density estimation to calculate the annual phenological cycle and anomalies from satellite imagery at the pixel level. By using this non-parametric technique, our algorithm is highly flexible and can estimate the probability density function of multiple phenological cycles even at moderate levels of missing data. By displaying pixel level anomalies, we quantified the intensity, spatial distribution, and temporal spread of insect outbreaks. To exemplify the procedure, we used 16-days (2002-2015) MODIS EVI composites to 1) reconstruct the leaf phenology of Chilean Patagonian forests and 2) detect EVI anomalies. The analysis showed that massive outbreaks (> 20,000 hectares) occurred during the growing seasons 2008-2009, 2011-2012, and 2014-2015, showing an increasing trend on the affected area along time. To facilitate the implementation of the method, a R package is freely available for all users.

outbreaks, remote sensing, time series,vegetation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2626 **Genotype and source population influence net primary productivity but not insect borer or canker damage in a cottonwood-willow common garden**

Garnas, J.* (1); Grady, K. (2); Parker, J. (3); Cooper, H. (3); Allan, G. (3); Whitham, T. (3)

(1) University of New Hampshire, Dept. of Natural Resources and the Environment, Durham, United States; (2) Northern Arizona University, Department of Forestry, Flagstaff, United States; (3) Northern Arizona University, Department of Biology, Flagstaff, United States

Abstract: Climate change is predicted to influence forests in myriad ways, not least of which by driving local maladaptation in trees. Such maladaptation could manifest as reduced growth, mortality or dieback in response to weather extremes, or altered susceptibility to insects and pathogens. Using data from a >16,000 tree common garden in Blythe, California planted in 2007, we examined diameter growth and biomass production in clonally-propagated Fremont poplar and Goodding willow from parent plants from 16 populations spanning a latitudinal and elevational gradient (5.4 degrees and 1300 m). We found a strong effect of tree genotype on growth in both 2010 and 2015 for poplar, but only for 2010 for willow. There was also a clear negative correlation between mean tree growth and "temperature transfer distance" measured as the difference in mean annual maximum temperature (MAMT) between the source population and the garden environment. Finally, we assessed generalized borer damage and wound-induced bleeding canker formation on poplar individuals but found only moderate evidence for a genotype effect and no clear pattern with respect to source population origin. These results suggest a key role for climate in this system where some aspects of tree performance (e.g., growth) might be more sensitive to local maladaptation than others (e.g., generalist natural enemies). Further, stand context, in particular intra- and interspecific competition, are important components of these responses. These findings provide a quantitative method for identifying which genotypes and populations are likely to perform best under various warming scenarios. They also reveal where local maladaptation might render traditional preference for local source material in restoration efforts implausible, and inform potential assisted migration alternatives. Such restoration decisions not only affect the survival of foundation plant species but also a broad community of organisms that these species support.

assisted migration; provenance; community genetics

Poster Exhibition Thursday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-2168 **Wood-anatomical characteristics and environmental signals of co-occurring oak (Quercus robur) and ash (Fraxinus excelsior)**

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Abstract: Timing and dynamics of earlywood (EW) vessel formation in ring-porous *Quercus robur* and *Fraxinus excelsior* differ, as well as the relation between leaf phenology and vessel formation. However, there is a lack of research addressing oak and ash as co-occurring species in order to evaluate their response to environmental changes, adaptation abilities and survival capabilities in mixed oak and ash stands, which are highly endangered by direct anthropogenic influence and climate change impacts.
Thus, the aim of our research is to study and compare growth response of *Q. robur* and *F. excelsior* to environmental variables and the relevance of potential climatic signals stored in anatomical structure of tree-rings. For these purpose, we analysed stem disks of 12 dominant or co-dominant mature trees of each tree species in Slovenian lowland forest. Wood structure was analysed on a cellular level with special focus on initial ring of EW vessels (density, size and area).
Preliminary results show, that EW vessels characteristics as well as widths of tree-rings, latewood and earlywood are not correlated in *Q. robur* and *F. excelsior*. Tree-rings of *F. excelsior* are considerably wider than tree-rings of *Q. robur*. In addition, in *F. excelsior*, EW vessel density is considerably higher with more stable size and lumen are than of *Q. robur*. EW vessels characteristics of both species are more closely correlated with temperature than precipitation, although the relationship is species-specific.
Although *Q. robur* and *F. excelsior* are both ring-porous tree species and grow at the same site, wood anatomy of the two species differ significantly and is subjected to different environmental variables. More detailed analyses of climate-growth relationships of co-occurring oak and ash will enable us to better understand their growth patterns and response to local environmental factors, which will be reflected in their capability to survive in changing conditions.

earlywood vessels, latewood, tree-ring

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1700 **Preferences for spatial structures in the dispersion of Ips typographus**

Hinze, J.* (1)

(1) Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg, Freiburg, Germany

Abstract: In 2016 a mark and recapture experiment with Ips typographus was made in the Black Forest National Park to analyze spatial preferences in the beetle's dispersion. This experiment will be repeated in 2017. The bark beetles were breed marked and released in stems of Picea abies at three different spots in and close to the forest. The beetles were caught with baited bark beetle slit traps. The traps were evenly distributed in the survey area and the spatial structure of the surrounding area of the traps was analyzed via remote sensing. The number of caught individuals can indicate the preference of I. typographus for the structures surrounding the traps. There is a big difference in the number of caught beetles between the traps that cannot be explained just with the distance to the release points. Most likely it is a combination of structures that attracts or repels the bark beetles. Once the attracting and repelling structure combinations are detected, we can create models from remote sensing data to create maps of the risk potential for forest land.

Ips typographus, dispersion, structure preference

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1111 **Fungal communities in soils under a Eucalyptus plantation in Zimbabwe**

Jimu, L.* (1); Mujuru, L. (1); Mwenje, E. (1)

(1) Bindura University of Science Education, Bindura, Zimbabwe

Abstract: The Australian genus *Eucalyptus* contains many timber-producing forest species and is extensively planted around the world. The domestication of *Eucalyptus* is thought have contributed to the global movement of microorganisms associated with this genus. The objective of this study was to identify the fungal microbes in soils under an economically important tree, *E. grandis*, from Zimbabwe. Soil samples were collected from a five year *E. grandis* plantation and miombo woodland, which was treated as the control. The internal transcribed spacer 1 (ITS1) nuclear encoded ribosomal RNA of the fungal communities in the soils was sequenced using the high-throughput Illumina MiSeq technology. Taxonomic composition assessment of reads recovered from soils under *E. grandis* revealed the dominance of Ascomycota (57.23 per cent), Basidiomycota (32.04 per cent), with lower representation of Glomeromycota (0.17 per cent), Chytridiomycota (0.05 per cent) and Zygomycota (0.04 per cent). Miombo soils were composed of Ascomycota (70.67 per cent) and Basidiomycota (22.5 per cent). Our findings have provided evidence that species belonging to Davidiellaceae, Mycosphaerellaceae and Teratosphaeriaceae occur in soils under *E. grandis*, increasing the chances that soils in plantations may be acting as sources of inoculums for some of the most important diseases of *Eucalyptus*. Furthermore, this study has identified diverse fungal species that form mycorrhizal associations with *Eucalyptus*. Further studies are therefore required to have better understanding of these fungi and whether soils may be contributing to the spread of pathogens.

Eucalyptus grandis, Illumina sequencing,Mycorrhiza

Poster Exhibition Thursday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-1867 **Illumina DNA barcoding reveals fungal communities in Pinus patula (Pinaceae) foliage**

Jimu, L.* (1); Magogo, C. (1); Mujuru, L. (1); Mwenje, E. (1)

(1) Bindura University of Science Education, Bindura, Zimbabwe

Abstract: Endophytic fungi play important roles as decomposers, mutualists and pathogens in ecosystems. In this study, we examined endophytic fungi in asymptomatic needles of *Pinus patula* collected from Zimbabwe. Needle samples were sampled from a mature plantation of *P. patula*. The needles were surface sterilised and genomic DNA was extracted using the Zymo plant/seed extraction Kit. The internal transcribed spacer 1 (ITS1) nuclear encoded ribosomal RNA of the endophytic community of *P. patula* needles was sequenced using the Illumina Miseq technology. Merging of paired end Illumina Myseq fastq reads resulted in 63948 sequences that were quality trimmed to a total of 44747 sequences. These were subjected to read clustering and resulted in the recovery of 78 OTUs, excluding singletons. These were dominated by Ascomycota (81.1 per cent) and to a lesser extent Basidiomycota (17 per cent). About half (51.2 per cent) of the total reads belonged to Eurotiomycetes, followed by Dothideomycetes (15.3 per cent), Exobasidiomycetes (7.9 per cent), Agaricomycetes (7.3 per cent), Sordariomycetes (7.2 percent), Leotiomycetes (2.9 per cent) and Ascomycetes (2.2 per cent). Predominant genera were *Aspergillus* (39.8 per cent), *Ramularia* (10.6 per cent), *Eurotium* (10 per cent), *Malassezia* (6 per cent), *Scleroderma* (5.5 per cent), *Pestalotiopsis* (4.2 per cent), *Lophodermium* (2.9 per cent) and *Strigula* (2.2 per cent). Besides *Lophodermium*, no other genus known to be seriously pathogenic to pines was recovered in P. patula. This supports the general observation that the species has remained free from disease problems.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2970 **Biotic forest disturbance induced by the hemiparasitic epiphyte Viscum album on the growth of Pinus sylvestris**

Kollas, C.* (1); Gutsch, M. (1); Lasch-Born, P. (1); Suckow, F. (1); Hommel, R. (2)

(1) Potsdam Institute for Climate Impact Research, Potsdam, Germany; (2) Eberswalde University of Sustainable Development, Eberswalde, Germany

Abstract: Biotic disturbances play a major role in current and future forest growth dynamics. Although the physiological impact of *V. album* on trees is widely understood, the extent of damage on the whole forest stand and the spread of the parasite remain uncertain.
We took growth increment cores from both infested and non-infested trees at a heavily infested stand (Berlin, GER) and quantified the impact of the hemiparasite. We fully harvested a subsample of trees to quantify the crown's share of leaf area (host/parasite) and to determine population dynamics of the parasite. *V. album* was implemented into the process-based forest growth model 4C connecting the water and carbon cycle of infected trees with the hemiparasite.
Next, growth of the studied pine forest stand was simulated from planting (1905) to current (2015) and future (2030) points in time applying mistletoe infection and using climate and silvicultural management as solely drivers.
Simulated mistletoe infection reduced tree ring width by ~30% compared to non-infested growth during the last 10 years of infection, which was confirmed by the data collected. Furthermore we show, for the German federal state of Brandenburg, current and future parasite-induced timber losses using climate change scenarios and *Viscum* monitoring data.

increment core, canopy, stand simulation, pathogen

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1769 **Impacts of E. polonica infection on defence and stem water transport of Norway spruce seedlings**

Rissanen, K.* (1); Paljakka, T. (1); Vanhatalo, A. (1); Linnakoski, R. (1); Kasanen, R. (1); Salmon, Y. (1); Mäki, M. (1); Prisle, N. (2); Bäck, J. (1); Hölttä, T. (1)

(1) University of Helsinki, Departement of Forest Sciences, Helsinki, Finland; (2) University of Oulu, Nano and Molecular Systems Research Unit, Oulu, Germany

Abstract: Because the predicted increase in drought and wind damages increasingly favours forest pathogens, more fundamental research on pathogen effects on tree physiology and defence is needed. We studied the effects of a pathogenic fungus *Endoconidiophora polonica*, on 50 Norway spruce clones (mean height 120 cm) in a greenhouse during the summer 2016. Treatments included infection, wounding (mock-inoculation) and intact control. The infection was assumed to trigger tree defence and suppress water transport in stem. The defence reactions of two infected and two wounded clones were monitored by measuring oleoresin pressure and stem emissions of volatile organic compounds. Water conductance, sap water surface tension, stem hydraulic conductivity and relative water content were measured from all the clones.
Infection and wounding did not trigger immediate response in oleoresin pressure or stem emissions, but after four weeks, the daily range and maximum of oleoresin pressure increased in the infected clones. They also emitted more isoprene that the wounded clones. Water conductance, surface tension, stem hydraulic conductivity and relative water content decreased in the infected clones. Our results show that the infection weakens trees by decreasing sap water surface tension, thus causing embolism. This renders trees more susceptible for hydraulic failure and secondary damages, probably especially in dry conditions.

E.polonica, P.abies, resin, VOCs, water transport

Poster Exhibition Thursday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-2087 **Phytophthora induced dieback alters canopy and forest floor solute chemistry in a New Zealand kauri forest**

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Abstract: Kauri dieback caused by *Phytophthora agathidicida* is a recent threat to the survival of the carbon-rich and climate-sensitive kauri (*Agathis australis*, southern conifer) forests in New Zealand. Throughfall (TF) and stemflow (SF) are important components of the hydrological and biogeochemical cycles of forest ecosystems. This is the first study on water-bound carbon and nutrient fluxes in a kauri forest. Our aim was to evaluate the effect of kauri dieback on dissolved organic carbon (DOC) fluxes and chemistry. Throughfall and SF collectors were deployed underneath the canopy of ten kauri trees differing in their health status. We also collected forest floor (FF) leachate using zero-tension lysimeters. "Infected" trees (n = 5) were characterized by yellowing of leaves, leaf loss and stem bleeding. Water fluxes were collected over one year. TF and SF were significantly more acidic than rainfall. Mean pH in TF was significantly lower in "infected" trees (5.23) compared to "healthy" kauri trees (5.57). The same tendency was observed in SF and FF leachate. Volume weighted DOC concentration varied considerably between seasons with higher values measured during summer (December to February). DOC concentration was highest in FF leachate (up to 100 mg/L) followed by SF (up to 45 mg/L) and TF (up to 25 mg/L). DOC concentration in TF, SF and FF leachate tended to be higher in "healthy" trees compared to "infected" trees. $SUVA_{254}$ values indicate that SF and TF from "healthy" trees contain more aromatic and humic-like compounds. In contrast, $SUVA_{254}$ values in FF leachate did not differ between "healthy" and "infected" trees. Our results show that kauri dieback affects DOC fluxes and chemistry in this carbon-rich kauri forest. Changes in water-bound fluxes and plant species composition will likely have short- and long-term effects on soil related processes and the forest carbon sequestration potential of these ecologically unique kauri forests.

kauri dieback, dissolved organic carbon, pH, SUVA

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3447 **Survey of Phytophthora-species in Åkersvika Nature Reserve in Norway**

Strømeng, G. M. (1); Brurberg, M. B. (1); Ørstad, K. (1); Talgø, V.* (1)

(1) NIBIO - Norwegian Institute of Bioeconomy Research, Ås, Norway

Abstract: In 2014, dead grey alder (Alnus incana) was observed in Åkersvika Nature Reserve, located near the town of Hamar in Hedmark county. Many trees had bleeding cankers commonly associated with Phytophthora spp. A planned expansion of the E6 highway through the reserve will involve felling of trees and removal of soil masses, which could potentially spread plant pathogens. Therefore, we surveyed the area in 2015 to determine presence of Phytophthora spp. Grey alder was the most severely affected host, but we also found extensive damage in Salix spp. and some damage in bird cherry (Prunus padus). Phytophthora spp. were detected in water and soil samples by baiting using rhododendron leaves, and from tissue samples by direct plating on selective agar (PARPH). Pure cultures were analysed by DNA barcoding (ITS-sequencing of the ribosomal DNA). Seven species were found: Phytophthora cambivora (grey alder), P. cryptogea (water), P. gregata (water, soil, bird cherry), P. gonapodyides (water, soil), P. lacustris (water, soil, Salix sp.), P. plurivora (water), and P. rosacearum (soil). We conclude that Phytophthora spp. have already severely affected the reserve, and fear that climate changes may worsen the situation. Careful handling and deposition of soil is necessary when road construction work starts.

Alnus, Salix, Prunus

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3591 **Is the plant pathogen Chondrostereum purpureum a safe biocontrol agent?**

Talgø, V.* (1); Stensvand, A. (1); Børve, J. (1); Strømeng, G. M. (1)

(1) NIBIO - Norwegian Institute of Bioeconomy Research, Ås, Norway

Abstract: Silver leaf disease (Chondrostereum purpureum) is reported worldwide from numerous woody plants. Fruiting bodies produce wind spread spores at temperatures above 0 °C. Infections occur through wounded tissues, and often result in mortality. The fungus has been found to kill shrubs like common snowberry (Symphoricarpos albus) and snowmound spirea (Spiraea nipponica 'Snowmound') in ornamental plantings in Norway. However, the most severe economic losses are related to commercial stone fruit production. Up to 40% infected trees have been observed where the disease has been left unattended. On susceptible plum cultivars, 5-15% infested trees are commonly observed. Removal of diseased materials is essential to keep the disease pressure down. In North-America and some European countries, commercial biocontrol products based on C. purpureum are available for controlling hardwood sprouting in forest regeneration sites and elsewhere. Based on observed damages, we are reluctant to the fact that the most virulent isolates are selected for biocontrol and question whether the decided distance of application no nearer than 500 m is sufficient to avoid wind spread to fruit producing areas and landscape plantings. Another concern is that the predicted increase in precipitation in the future may further add to the damage potential of the fungus.

silver leaf disease, forest, fruit orchards

Poster Exhibition Thursday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-3391 **Abundance of parasitoid Hymenoptera decreases along a gradient of phylogenetic diversity of saproxylic beetle communities**

Vogel, S.* (1); Thorn, S. (1)

(1) Universität Würzburg, Rauhenebrach, Germany

Abstract: Parasitoids play a major role in controlling forest pests and are are adapted to a certain range of host species.This specialization increases the efficiency of foraging but also decreases the ability to acquire new
resources. Therefore, host switching most commonly occurs between closely related species, which share morphological and physiological similarities. However, empirical tests of this hypothesis on a community level are lacking. Here, we used data from stem-emergence traps mounted on experimentally felled spruces to test the effects of abundance,species richness and evolutionary proximity of saproxylic beetle communities (hosts) on abundance and species density of parasitoid
Hymenoptera. We revealed, that abundance of parasitoid Hymenoptera increases with increasing mean evolutionary proximity of saproxylic beetle communities, whereas species density remains unaffeected. However, species density of parasitoid Hymenoptera increased with their increasing abundance. Our study hence provide
strong evidence for host switching by parasitoid Hymenoptera among species of in saproxylic beetles dependent on evolutionary proximity.

Evolutionary proximity, host switching

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3405 **Phytophthora species associated with woody plants in Macedonia**

Risteski, M.* (1); Jezic, M. (2); Curkovic Perica, M. (2); Woodward, S. (3); Rusevski, R. (4); Sotirovski, K. (1)

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Abstract: Surveys were carried out in 15 sweet chestnut populations, 15 apple orchards and 7 forest and ornamental nurseries throughout Macedonia for presence of collar and root lesions, rot and crown symptoms on trees and seedlings. Over 350 soil, and 50 bark samples were collected from both symptomatic and asymptomatic plants. Samples were baited using leaves of Prunus laurocerasus, Fagus moesiaca, Quercus spp. and Malus spp., and used V8 PARPNH and CMA+ selective media for isolations. DNA was extracted from cultures of 255 isolates, amplified by PCR using ITS4 and ITS6 universal Phytophthora primers and the products sequenced. Comparisons with sequences in a Phytophthora database identified 7 isolates of P. cambivora, all from chestnut trees or related soil samples, 1 of P. cinnamomi (Chamaecyparis lawsoniana - nursery) and 1 isolate of P. gonapodyides (beech). Five isolates of P. cactorum, 3 of P. megasperma, 2 of P. plurivora, 1 of P. rosacearum and 1 of P. citricola were obtained from apple trees or orchard soils. This report is the first to identify these species in Macedonia.

Collar rot, root rot, lesions, DNA, Phytophthora

Poster Exhibition Thursday

208 - Social and Economic dimensions of forest health: Contributing to a biosecure future

KG II - HS 2121 (Uni Freiburg)

IUFRO17-968 **Public perception foresters of invasive ash dieback pathogen arrival in Serbia**

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Abstract: Hymenoscyphus fraxineus (anamorph Chalara fraxinea) and Phytophthora spp., endanger the state of health of forest ecosystems, cultures and nurseries in Serbia. The aim of the article is what the public in the field of forestry in Serbia thoughts about the appearance of H. fraxineus (attitudes, values and understanding) and are they informed about the ash dieback pathogen arrival in Serbia. The respondents were the representatives of Ministry of Agriculture and Environmental protection, public enterprises, national parks, academic society in forestry, etc. There were 54 respondents. The survey has been created for getting information on public perception of arrival of H. fraxineus in Serbia. Survey participants answered that white ash is very important for Serbian forestry (55% of them), as well as narrow-leafed ash (55%). App. 27% of respondents were informed about the drying ash in Europe. 55% of respondents know what causes fungi H. fraxineus, and 91% of them are not aware that the disease is present in Serbia. About 64 have indicated what are the damages which cause this disease. 64% of respondents think it is very important to take administrative measures to prevent the introduction of this disease.

Hymenoscyphus fraxineus, public perception

Poster Exhibition Thursday

86 - The science of tree health and how we can: Multidisciplinary research from the Tree Health and Plant

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3129 **PHYTO-THREATS: A multi-disciplinary approach to address global threats from Phytophthora species**

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(1) Forest Research, Roslin, United Kingdom; (2) James Hutton Institute, Dundee, United Kingdom; (3) Centre for Ecology and Hydrology, Wallingford, United Kingdom; (4) The University of Edinburgh, Edinburgh, United Kingdom; (5) Centre for Ecology and Hydrology, Penicuik, United Kingdom; (6) Science and Advice for Scottish Agriculture, Edinburgh, United Kingdom; (7) 7Animal and Plant Health Agency, Sand Hutton, United Kingdom; (8) University of Worcester, Worcester, United Kingdom; (9) Forest Research, Farnham, United Kingdom

Abstract: PHYTO-THREATS is a multidisciplinary THAPBI-funded project which aims to address global threats from invasive Phytophthora species. The project team, drawn from seven different institutes across Britain, will (i) examine the distribution, diversity and community interactions of Phytophthora in UK plant nursery systems, (ii) provide the evidence base for a voluntary nursery 'best practice' accreditation scheme to mitigate further spread, (iii) identify and rank global Phytophthora risks to the UK and (iv) gain a greater understanding of the evolutionary pathways of Phytophthoras. Stakeholder participation is integral to the project both for nursery sampling to assess Phytophthora diversity under different management systems as well as social and economic assessments of attitudes towards a nursery accreditation scheme. A substantial database has also been created detailing the distribution and biological traits of all known Phytophthora species globally. This database will be used to model the risk posed by new Phytophthora arrivals to the UK from source regions through trade networks, providing novel information to UK Plant Health Policy. For the fourth objective, targeted genome sequencing of three Phytophthora species will help fill in gaps for comparative analyses of all available Phytophthora genomes to help us understand pathogen evolution and adaptability, particularly on woody hosts.

Phytophthora, risk, trade

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1678 **Natural Plant Oils Against Early Instar Larvae of Pine Processionary Moth**

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Abstract: Pine processionary moths (PPM) belonging to the genus Thaumetopoea (e.g. T. wilkinsoni Tams. and T. pityocampa Schiff) are a major pest of pine in Europe. PPM larvae damage and debilitate trees by feeding on their foliage and can be a direct cause of tree death. In addition, the larvae possess urticating hairs which are a serious public health hazard. Botanicals such as essential plant oils offer an environmentally friendly method of pest control. The current study investigated the use of essential oils of ginger, eucalyptus and rosemary. These were tested at three different concentrations (3, 1 and 0.1%) against 1st instar larvae and nest of 3rd instar larvae. The pine leaves were dipped into the emulsion then incubated in Petri dishes. For each treatment ten larvae were used with five replicate per treatment. The whole study was repeated twice. Ten ml of 1% essential oils were injected inside the nest of 3rd instar larvae at laboratory and field conditions. Only ginger oil consistently caused 100% mortality 4 days post treatment (pt) whether used at 1% or 3% concentration. Ginger oil used at 0.1% concentration caused 100% mortality 9 days pt. Neither eucalyptus nor rosemary caused more than 40% mortality 4 days pt at all the doses tested. However, substantial mortality was observed at the highest dose 9 days pt. In the laboratory conditions, 1% concentration of ginger had larvicidal effect inside the nests containing 3rd instar larvae. In the field conditions, all essential oils were found to be very effective. Larvae appeared to avoid all botanical treated leaves, moving to the periphery of the Petri dish. There was very little feeding damage suggesting that the botanicals were also powerful antifeedants. The actual cause of death is unclear but may be a combination of starvation stress and contact insecticidal activity of the botanicals. The use of botanicals in the control of PPM larvae is discussed.

Pine processionary moth, essential oils

Poster Exhibition Thursday

159 - Developing the dialogue about forests and forestry with society - the challenge to tell good stories

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3103 **Forestpedagogy - unique form of forest communication and active dialogue with public**

Jaloviarová, V.* (1); Loyová, D. (1); Melcerová, A. (1); Sarvas, M. (1); Selesova, D. (1); Taraba, M. (1); Navratil, R. (1)

(1) National Forest Centre, Zvolen, Slovakia

Abstract: Forestry community needs to make a serious communication and an active dialogue in society. Its presentation to public could be done by unique form with use of learning by doing methods of Forestpedagogy. Two projects are mentioned as an example: Junior Forest Academy and Forest Hidden in a book. The poster presentation is focused on the introduction of projects, with the emphasis on the cooperation among four different subjects: the university (Forestry Faculty in Zvolen, Slovakia), basic schools in region, libraries and the forestry community. The main role in both projects belongs to forest pedagogues who active ensure environmental and forestry issues presentation to children, youth and adults. The first project Junior Forest Academy is unique in realisation during one school year in the setting of Forest faculty and presentation of research result. The second one Forest hidden in a book presents that the product - a book has its origin in the wood and it comes also from the forest.

Forestpedagogy, learning by doing methods

Poster Exhibition Thursday

40 - Engaging equality: The construction of gender and forest through processes of gender mainstreaming

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2497 **Equality in examinations**

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(1) University of Luebeck, TransferConsult, Luebeck, Germany

Abstract: Bettina Jansen-Schulz, University of Lübeck
Equality in examinations
The construction of gender and diversity examinations in Forestry through the strategy of Gender Mainstreaming
1.Definition of concepts used: Gender
2.Research Context: gender in teaching
3.Specific area of study: gender education and gender-orientated examinations in forestry
4.Conclusions: concepts of gender-orientated examination.
In most of the faculties and disciplines in German universities very often the results of female students are better then those of male students, even in some STEM-disciplines. In forestry the number of female students is increasing. Whether their results in examinations are better I will show on the poster with some descriptive statistics level.
To encourage more female students for forestry study it is necessary to have a glance not only on the contents and didactics of the modules but also on the dimensions of examination.
One result of gender research on female students in male dominated disciplines transparency is one of the categories that will encourage (beside a lot of other categories) more women to study STEM-disciplines and to get through the studies successfully. Gender oriented examinations are one of the categories we will look at. Even when the female students have better results, there are not enough of them. Forestry is an extremely international and intercultural discipline. Therefore we have to look also on diversity categories in examinations.
With the four steps of gender mainstreaming: analyses, goals, approaches, Evaluation I will show in the poster gender and also diversity dimensions for examinations:
interculture, structures, contents, didactics, methodics, individual aspects.
I will come the concept of "constructive alignment" and work out further categories and dimensions for gender oriented examinations in forestry and how they can become more transparent.

gender, examinations, transparency

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3098 **Gender inequalities. Situation in Polish State Forests National Forestry Holding**

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(1) The Warsaw University of Life Science, The Faculty of Forestry, Warszawa, Poland; (2) The State Forests Bielsko Forest District, Bielsko-Biala, Poland

Abstract: Poland at a law level both ensures and strongly underlines formal equality of men and women. Forestry is situated in a broad branch of male dominated professions.
Contemporary forestry perceives gender equality as important aspect of sustainable development. Presented research, conducted by Faculty of Forestry, supported by The State Forests, the biggest company in Polish forestry, employing more than 25 000 people and managing 75% of all forests in Poland.
Methods used in presented paper were based on previously elaborated and published surveys. The State Forests were treated according to internal division on 17 regions. Two different surveys were distributed: in HR units covering obligatory politics and hard data concerning number of employees, salaries, education level, structure of management considering gender division and directly among employees, including their individual opinions.
The questions were grouped covering 7 areas: recruitment, protection against dismissal, access to trainings, access to promotion, salaries, solutions supporting family/job balance, protection against discrimination, mobbing and sexual harassment.
Received data were analyzed in 17 regions separately, ranking them in enlisted areas, pointing strong and weak areas of gender management. There were shown strong differences in regions despite common base of law and central management. Access to trainings was identified as the less problematic area in the context of gender equality, salaries - as gender dependent in favor of men. According to data received in 2010 and compared with the latest statistics the share of women is still about 25% and lower than 10% at management level.
Gender Index, the result of the research, let endorse procedures improving gender equality in regions which were ranked at the bottom of the list. In case of as strongly diversified enterprise as SF NFH, benchmarking using own internal data shall cause positive changes in equalization of all employees' chances.

Gender Index, equality, forestry, women

Poster Exhibition Thursday

40 - Engaging equality: The construction of gender and forest through processes of gender mainstreaming

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1884 **Gendered change and political space: seeing what/who's future in the Swedish forests?**

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Abstract: In challenging gender inequalities, gender mainstreaming has been emphasized as the main policy process and tool of change. In Sweden, the national gender equality strategy of the forest industry has put the spotlight on one of its most gender-imbalanced and gender-segregated workforces. Engaging a range of actors, the strategy has contributed to a number of processes on various levels - which has been the study object of a number of research projects. A composition of studies over the last years, illustrate how, within forestry, not only organizations, but also, change is gendered and shaped by other forms of social division and domination. They also indicate how the understanding of change, gender and gender equality is interviewed and shaped by the governing technologies of neoliberal (e.g. standards, certification, audit, LEAN), market-oriented ideologies (e.g. economic growth and modernity) and the construction of the forest as a governable resource - which further limits the space for structural change and underlines the present challenges of gender mainstreaming. It thereby alters the interaction of the discourses of the politics and the political. In ignoring conflicts and power, the present framing of gender equality measures both challenge the modes of deliberation that mask domination and to facilitate transformative processes.

neoliberalism, mainstreaming, governance, forestry

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4083 **How far has Sweden come in implementing gender equality in the country's forestry education?**

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Abstract: The forest industry plays an important role in Sweden,
both financially and by providing nearly 60,000 job
opportunities for the swedish population.
Nevertheless, this industry is far behind in the terms of
gender equality, and even though there has been a lot of talk
about changing this during the past few years there's still a lot to be done.
To state an example; the mayority of the forestry
companies in Sweden say they want to hire more women, but have
trouble making women stay in their company once this goal has been achieved.

The highest forestry education in Sweden is given
at SLU (Swedish University of Agricultural Sciences) and this is
where students learn about the social norms
in their future workplace. Therefore, it is also here that
the future foresters should learn about
the importance of equality and mutual respect. A statement not
many would disagree with, but the way this it is implemented in the education is still unknown.

To uncover how gender equality is being presented and processed throughout
the education in forestry in Sweden, all people in charge for the different courses
will be contacted and interviewed about these matters.

The study hopes serve as the beginning of a larger survey about how
gender equality is implemented as a preventive measure in the
forestry education programs in Sweden.

Sidenote: this is a study that is planned to have been completed in April 2017.

equality, Sweden, forestry, education, gender,

Poster Exhibition Thursday

40 - Engaging equality: The construction of gender and forest through processes of gender mainstreaming

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2341 **Knowledge, skills and work: gendered opportunities and structures in Swedish forestry**

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Abstract: Specific types of knowledge and skills have been essential to the establishment of forest professionalism and the human-nature relations in forestry. In the process, the male body represent a key asset in the development of the work organizations of forestry, and thus to the male dominance of Swedish forestry at large. Lately, women have entered forestry education and the labour market, but as the organization rest upon segregation, the gendered division of labour and power remains. However, the segregations has additional organizational consequences, effecting the performance and attractiveness/competitiveness of the individual organization and the entire sector. This has been addressed by the Ministry of Rural Affairs and highlighted in the National gender equality strategy for the forestry sector that was launched in 2011. In this paper, studies carried out over the last five years, are compiled, showing how economic arguments of diversity has open up specific spaces within forestry organizations by demanding emotional and aesthetic labour. Yet, through the current approach of gender mainstreaming, women are perceived as objects of change within existing structures and organizations (status quo). In being primarily viewed as a process of modernisation to increase productivity and competiveness, gender equality runs the risk of getting trapped in the rationalities of economic growth and further cementite the gendered notions of knowledge, skills, work and the forest.

professionalism, forest, labour, bodies

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4080 **Women entrepreneurs in the Swedish forestry - An identity and a business in transition?**

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Abstract: The forestry sector in Sweden is one of the most gender-segregated in Sweden, although 38 % of the Swedish forest owners are women. The gendering of the sector as a distinct male arena has led to a number of negative outcomes, not just for gender equality, but also for economic stability and ecosystem vitality. Gender inequality indicates a policy failure, and in order to address these concerns the government has introduced various soft-governance action programs and strategies. The results of these efforts have so far proven to be largely ineffective, and in the light of this, it is of particular importance to understand what expressions women's entrepreneurial identities may take within the framework of the dominant gender order. With this poster I explore the potential of 'altering' gendered norms in the sector under change. Must forestry be 'encoded' in feminine terms, that is, are we moving towards a 'feminized forestry', or are women to adopt the gender male stereotypes, thereby reproducing male experience as a preferred normative value?

Women entrepreneurs;Gender equality; Forest sector

Poster Exhibition Thursday

12 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1169 **Community based Forestry: the vehicle of establishing local institutions, and building socio-ecological resilience in Nepal**

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Abstract: Community-based forestry (CBF) of Nepal is becoming a new identity for international recognition. CBF in this paper implies the different model of community involvement in forest management and which implies the community forestry, collaborative forest management, leasehold forestry, public land forestry and buffer zone forest management. In these management regimes, the government authorities have handed over the sustainable management and their sustainable utilization rights to the local communities under approved operation Plan, and user's constitution for the defined period.
The paper is based on the systematic review of different studies, proceedings, journal articles, and the study conducted by the HELVETAS Swiss Intercooperation Nepal to analyses the role of community forestry in land use change and forest cover change in 2014-2015. Data shows that there are about 31000 community based forestry groups managing about 1.9 million ha of forest across the country. A very recently updated data from Department of Forest of Nepal shows that, the community Forest users groups (CFUGs) alone reached to 18,960 with the membership household 2.2 million and managing 1.9 million ha forest land. By these community lead forestry and forestry sector as a whole contributes to generating jobs, and thereby providing different livelihood options, and at the same time contributing to build ecosystem resilience through sustainable management of forest resources.

Community forestry, resilience, livelihood, state

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3231 **Mapping the future market potential of small-holder tree planters - Perspectives from Southern Highlands in Tanzania**

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Abstract: In the rapidly growing Tanzanian economy, increasing demand for timber and limited supply from industrial plantations have opened a new livelihood opportunity for small-holder farmers, and a tree planting boom is being experienced in the Southern Highlands of Tanzania. In the absence to extension and support services and statistics, it has not been clear how well farmers are able to meet the market demands for wood quality, and how they access the markets and negotiate prices. The data to clarify the role of small-holder tree planters in the wood value chain was collected through 120 semi-structured tree-planter and non-planter interviews and in four villages, and from interviews of timber buyers and processors, and were analysed descriptively. The results indicate that small-holder tree planters have serious problems with wood quality. However, the strong market demand has created dual markets from both higher quality industrial plantation wood and lower quality small scale supply. Capacity building is nevertheless needed to improve the small-holder produced wood quality to ensure the long-run tree planting livelihood and competitiveness of small-holder producers in the markets.

small-holder, tree planting, Tanzania, value chain

KG II - HS 2121 (Uni Freiburg)

IUFRO17-803 **The legitimacy of certification actors in forest climate governance**

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Abstract: Non-state actors such as NGOs and companies play an important role in the current climate regime. An example are project developers and standard setting organizations that design, implement and certify carbon mitigation projects for emission trading schemes that are also relevant for reforestation or forest conversation projects related to the UNFCCC. These actors are involved in the governing of public affairs by setting rules how to adequately mitigate and monitor carbon emission reductions and by mobilizing and driving private climate finance (Abbott, 2012). This raises critical questions about legitimacy such as who is responsible for what actions and how democratic control can be achieved. In this context, questions arise as to how legitimacy of non-state actors in transnational forest climate governance can actually be conceptualized and analyzed. Classical concepts of legitimacy are limited for analyzing governance arrangements that operate transnationally, in varied actor constellations and cooperate in networks. Specifically, it may matter to distinguish between legitimacy and (de-) legitimization which is hardly considered in empirical studies. While the former means the state or quality of affairs, the latter refers to the specific process or procedures by which consent (or dissent) with political actors or institutions is expressed (Abromeit & Stoiber, 2007). Multi-stakeholder networks are characterized by a high degree of independence from state actors and work across several governance arenas simultaneously ranging from local implementation contexts to international climate negotiations. The objective of this review paper is to elaborate (in) how (far) existing theoretical concepts of legitimacy are able to grasp and analyze relevant processes in emission trading projects.

legitimacy, emission trading, certification

Poster Exhibition Thursday

12 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-690 **Adapted Institutional Environment and Sustainable Resource Access: Evidences for Co-Developing Value Chains of Forest(tree) and Agricultural Products in the Amazon**

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Abstract: Given the lack of access of forest dependent rural dwellers to natural resources and markets as well as the lack of an enabling institutional environment for reconciling biodiversity conservation and livelihood strategies in the Amazon:
How do formal and informal institutions affect the access to Brazil nuts (BN) and NTFP markets by upstream actors of the BN value chain (VC) in the Lower Amazon region?
The formal institution analyzed is the 'Term of Compromise' (ToC) and the informal one is the 'debt-peonage system' institutionalized in the Amazon. The ToC is a legal instrument for overcoming conflicts among Brazil's Ministry of Environment and traditional populations concerning resource access in Protected Areas (PAs).
Qualitative and quantitative data were collected from 'community' to national level, including through a survey with 185 households as well as key-informant interviews (2012-2015).
The analytical framework helps capturing how both formal and informal institutions affect the access to resources and markets by upstream VC actors. It serves as an innovative input for inclusive value chain development (VCD) of forest(tree) or agricultural products in any rural context and landscape.
Findings indicate: (i) formalization of resource and market access restrictions per ToC has reinforced unbalanced trade relations among BN gatherers and buyers already institutionalized per debt-peonage; (ii) self-reliant sustainable BN VCD depends on democratic participation in decision-making for locally adapted ToC by transforming the governance structures of councils for managing PAs from 'consultative' into 'deliberative' ones, while co-shaping a conducive context-sensitive institutional environment, policies and service provision; (iii) 'sustainable upgrading' of the position of upstream VC actors builds on organization of smallholders in 'well-managed' cooperatives with active members. Finally, evidence-based policy recommendations are provided for co-achieving SDGs.

access, institution, supply chain, sustainability

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4075 **Forest Potential in the European Climate Policy Framework**

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Abstract: The EU LULUCF strategy has resisted the strong mobilization of forests and forest-based resources in the climate policy framework (Ellison et al 2014). Only recently has the European Commission proposed strengthening the role of forests (COM(2016)479 final) with a legislative proposal that would set up a separate forest "Pillar" and propose targets for additional carbon sequestration in standing forests. Forests and forest resource-based climate change mitigation potential is frequently downplayed by some of the major actors addressing UNFCCC negotiations on commitments for reducing emissions (see e.g. UNEP 2012).

We estimate forest potential in the EU climate policy framework based on multiple scenarios. Currently, EU forests compensate some 13% of European emissions. But as emissions continue to be reduced through 2020 and EU 2030 climate policy frameworks, the role and potential impact of forests will rapidly increase.

The real question then becomes: why the EU is so resistant to promoting pathways of the type proposed? We will discuss preferences for conservation over the utilization of the (European) forest resource, concerns about 'forest permanence' and finally resistance to the idea of "offsetting". Yet, whether such concerns represent real 'threats', or whether they may be classified as misperceptions will be analyzed based on quantifiable data. While conventional wisdom suggests an important tradeoff exists between exploitation of the forest resource and reductions in a hypothetical forest sink, we will illustrate that this is only a short-term problem. Analyzing the 20th century evolution of European forests and forestry, not only is this perceived tradeoff illusory, forest management has indeed played an impressive role in the restoration of European forests. For this reason, and others, concerns related to forest permanence, conservation and the ills of offsetting seem less compelling.

Climate Policy, LULUCF, EU, Forest, Mitigation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3551 **Public values are incorporated into forest governance in many ways at multiple levels**

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Abstract: A major challenge in forest governance is incorporating multiple and often competing values. Studies into values of the public reveal diversity in the importance attached to productive uses of forests relative to other values such as life support and experience. We draw upon 15 years of social research to describe ways value based tensions are resolved at multiple levels of governance. At international and national levels, C&I frameworks express the breadth of what is valued about forests. Findings of cognitive interviews suggest while these frameworks incorporate many values of the public, experiential values of forests may be under-represented. At regional level, policy and planning approaches that seek to integrate multiple values through negotiation have shown strong potential, but have also struggled to incorporate the full breadth of public values. At practice level, values have been integrated through silvicultural approaches, such as variable retention forestry. At ground level, community based forest decision-making remains challenging in situations of value conflict. In conclusion, value conflict is managed in a range of ways at multiple levels, with the main work of integrating multiple values occurring at regional level, for example through regional planning processes that are supported by broad organisational structures and innovative silviculture.

Values; Forest policy

Poster Exhibition Thursday

12 - Open Session

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1687 **Governing the trade of endangered wild tree species: the case of Prunus africana**

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Abstract: Prunus africana is an Afromontane tree, locally used for fuel, timber and traditional medicine in Cameroon. The bark is also internationally traded as the principal ingredient in pharmaceuticals and health products. Growing international demand has led to concerns of over-exploitation of wild stocks, its appearance on the IUCN Red List in 1998 and CITES trade restrictions since 2005. Cameroon was the largest world exporter, but enacted a self-imposed moratorium from 2007 to 2010, similar to other African countries. These measures affected the livelihoods of people and companies dependent on the international trade but provided a respite to decades of intense harvesting, and a chance to reassess the species status and its governance arrangements.

This paper examines the different policy and governance responses across Africa and by stakeholders globally to these challenges and their consequences. A literature review, interviews and policy analysis are used to investigate responses such as the development of national management plans, inventories of wild and planted trees, the development of nurseries and planting, genetic analysis, harvesting guidelines and new trade regulations. Given these findings, the actuality of the endangered status of Prunus africana is assessed and the consequences of these different governance arrangements for more sustainable international trade, species conservation and livelihoods are explored. Legislation alone has not been able effective, and a more effective combination of multi-level customary, international agreements, market-based voluntary value chain arrangements is essential to ensure the survival of this species and its continued trade.

Non-timber forest product, trade, governance

KG II - HS 2121 (Uni Freiburg)

IUFRO17-235 **A decade of adaptation to climate change among rural communities in Southern and Eastern Africa: The role of Forest ecosystems**

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Abstract: Future climate change forecasts suggests that sub-Sahara Africa will continue to face negative impacts of climate change. This demands the developing of national level adaptive strategies to help improve the adaptive capacity of local people to climate change especially in rural households. What roles are forests and woodlands products playing in shaping adaptation to climate change? This paper explores the role of forest ecosystems in current adaptation strategies to climate change in southern and Eastern Africa drawing on evidence from the country specific National Adaptation Plans of Action (NAPAs). A content analysis of nine (9) NAPAs from southern and eastern African countries (Angola, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mozambique, Tanzania, Uganda and Zambia) was conducted to understand national adaptation strategies proposed in different countries to adapt to climate change. Additionally, expert interviews were conducted with national experts responsible for implementation of the measures to examine implementation challenges. Additionally, opportunities and challenges of implementation of adaptation strategies are discussed drawing on evidence from adaptation research conducted in southern and eastern Africa over the last decade.

Climate change; Livelihoods; Adaptation; Africa

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3910 **Policy Mix for Reducing Deforestation from Palm Oil Production**

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Abstract: This paper deals with the policy instruments targeting at one of the leading global drivers of tropical deforestation - the production and trade of palm oil. It uses a law and economics perspective and a policy instruments analysis approach. Palm oil as one of the most inexpensive vegetable oil ingredients used ubiquitously worldwide, has caused severe depletion of tropical natural forests, secondary forests or carbon-rich peatlands. This paper first summarizes the policy measures taken at both international and national levels by private and public institutions, including the roundtable certification schemes, the zero deforestation objective, the mechanism of Reducing Emissions from Deforestation and Forest Degradation under the international climate change regime, public procurement policies, moratorium and national land use planning coordination, etc. Then it further addresses their current gaps. Subsequently, based on the law and economics theories and literature, it discusses potential instruments that could be introduced or strengthened and suggests a policy mix of private enforcement, conditional payments and public land strategy. Finally, it concludes with possible synergies brought by the proposed instruments combination.

oil palm plantation, deforestation, policy mix

Poster Exhibition Thursday

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IUFRO17-1240 **Will the DRC community forest model be viable?**

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Abstract: Since the second half of the 2000s, several options on the implementation of community forests in the Democratic Republic of Congo (DRC) have been discussed in the country's technical and political circles. Propositions and pilot testing have increased in the last 2-3 years, in parallel with the promise of substantial international funding. As a result, several initiatives have been tested or are under development in the forest area of the DRC. Yet, the regulatory framework remains incomplete and very much debated. In the absence of a clear regulation and indeed political direction, the funding of current initiatives is often proposed with divergent purposes and conducted with different approaches.
We reviewed the current experiences and found that none has conducted an estimation of the potential financial return of the business models they elaborated for/with the concerned communities. We thus conducted a socio-economic feasibility study for three case studies in Orientale province, by estimating the costs of developing/implementing activities and the benefits expected for communities on a 5 years horizon. Four main results are drawn from this analysis: (1) all experiences show a negative financial performance, the initial and implementation costs being significantly above the medium-term profits; (2) the main benefit expected by communities is clarifying and securing their customary land tenure; (3) a majority of the activities conducted in the framework of the 'community forest' model deal with rural development and not forestry operations per se, and therefore could be promoted and conducted without having to engage in a process of designing, establishing and maintaining the community forest model; (4) local organizations set up to oversee community forests are complex, expensive and little known by most inhabitants. We conclude by discussing and proposing a few models that could improve the effectiveness of community forestry in the DRC.

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IUFRO17-86 **Institutional models in forestry and nature conservation and climate change mitigation measures in selected European Union and western Balkan countries**

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Abstract: This paper presents the analysis of the institutional frameworks and measures for climate change (CC) mitigation in forestry and nature conservation in selected European Union (Germany, Austria, Slovenia, Croatia) and Western Balkan (Federation of Bosnia and Herzegovina and Serbia) countries.
Primary data were collected through interviews with representatives of public administration and organizations in forestry and nature conservation. Respondents' perception of CC and their attitudes towards institutional and organizational competencies as well as prevailing institution's and organization's strategies and measures for CC mitigation (incl. measures related to changes in organizational structures, processes and instruments) were analysed and compared across the countries. In addition, attitudes towards the needs for new and the improvement of existing decision-support systems and cross-sectoral cooperation were investigated. Secondary data were collected from internal reports, strategic and legislative documents and a content analysis was conducted.
The paper identifies different institutional and organizational models and approaches in the sectors of forestry and nature conservation as well as the division of responsibilities related to CC in selected countries. The authors focus on the reasons behind the emergence of the particular institutional models and provide an explanation for the differences in economic, regulatory and informational measures regarding CC mitigation (e.g. related to the replacement of non-renewable energy sources, carbon sequestration and use of wood products) which are specific to the investigated countries.

institutional models, measures, climate change

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IUFRO17-2815 **The Ecosystem Approach, Ecosystem Services and Established Forestry Policy Approaches in the UK**

Raum, S.* (1)

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Abstract: A series of approaches have been proposed for natural resource management and biodiversity conservation in recent decades. This paper contributes to a lively contemporary debate surrounding the ecosystem approach and ecosystem services, by examining how these two interrelated but distinctly different concepts are currently understood and adopted within UK forestry and in the context of established forestry policy paradigms. For this purpose, I undertook a review of the scholarly literature and legal and policy documents which have been triangulated with a survey of the attitudes, interpretations and opinions of forestry stakeholders' through expert interviews. The analysis suggests that in the UK forestry sector, as elsewhere, the frequency of, often broad and ambiguous, approaches to natural resource management and nature conservation in general, and forestry policy and management in particular, are causing confusion amongst some stakeholders, who, unsurprisingly frequently conflate concepts seemingly without understanding the details. However, a clear understanding of the differences and similarities of these key concepts, stemming from overlapping but different disciplines, is important for successful policy implementation and sustainable forest management.

sustainable forestry, ecosystem services, politics

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IUFRO17-2816 **Reasons for Adoption and Advocacy of Ecosystem Services in UK Forestry**

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Abstract: The ecosystem services concept has enjoyed widespread interest in recent years. However, who is behind the strong momentum towards ecosystem services and why is less well known. In this paper I aim to shed light on this by looking specifically at advocates of the concept, using forestry in the UK as an example. I explore the motivations for accommodating or actively pursuing ecosystem services thinking in this important sector through interviews with experts. Four prominent groups with a specific interest in the ecosystem services concept in the context of UK forestry are governmental organisations, non-governmental conservation organisations, private forest owners, and the timber and forest industry. These stakeholder groups are interested in this new perspective, chiefly, but not exclusively, because it is required under international obligations; it is in line with dominant market political philosophy; it holds the promise to include the environment more fully into prevailing economic decision-making processes; it helps to draw more attention to biodiversity conservation; it holds the promise of new sources of income from both public and private sources; and it can be used as a convenient argument to promote further tree planting.

UK forestry, policy, ecosystem services, advocacy

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IUFRO17-2088 **Changes of private forest ownership and characteristics of the "new forest owners" in Japan**

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Abstract: Tenacity of property conservation was pointed out as Japanese private forest owners in previous studies. However, the many owners who had involved in plantation have reach 80's. And it is observed that some owners have been selling their property to other individuals and corporations without normal family inheritance process since around the 2000. The reasons why previous owners sold out the assets and characteristics of the new forest owners should be found out for forest policy. This study aims to clarify the actual situation of changing private forest ownership in Japan based on statistical data of forestry census, literature reviews and case studies. There were two trends under low stumpage price and depopulation in mountainous areas. One trend was observed that a great sawmill company have been collecting forest stands with land ownership for resource acquisition. And other trend was that many young people lived in urban areas have been buying/renting the small-scale forests and transfer to rural area since 2011 when occurred big earthquake and nuclear accident.

Forest ownership, Inheritance, Land sales, Japan

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IUFRO17-955 **Simulating wood markets with an agent-based model**

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Abstract: With agent-based modeling (ABM), it is possible to analyze markets by modelling all market participants (the agents) individually. This method has been widely applied in different fields, such as market simulation, social simulation, and many more. We built an ABM of the Swiss wood markets covering the assortments sawlogs, energy wood, and industrial wood, each assortment further divided in softwood and hardwood. The ABM consists of nine different agent types having the role of suppliers, demanders, and intermediaries. We organized several workshops and conducted six surveys to have enough data to create an ABM with a rigorous empirical foundation. A strong focus lies on the decision-making system of the simulated market participants, which is based on discrete choice experiments and random utility theory. We validated our ABM with data from different sources. Data from the federal statistical office were used to validate prices and traded amounts in the last 15 years. Data from own surveys were used to validate further details of the model, such as number of interactions between agents, typical delivery quantities per supplier, or transportation costs. The model is now used to simulate different market scenarios, such as market entry and exit of bulk consumers, the role of intermediaries, or set-asides of wood production capacities and the impact of policy instruments.

agent based model, wood markets, wood availability

Poster Exhibition Thursday

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IUFRO17-1278 **A deadly dance of discourses: Competing forest development narratives for Peru's Eldorado**

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Abstract: Peru's territory is 62% under forest cover, the largest part of which is located in the country's eastern Amazon basin. Government's efforts to incorporate the territory in national economic development and modernization strategies have variously considered the interests, let alone the visions and aspiration of local residents. Given the historical contestation over Peru's Amazonian territory and its resources, different stakeholders have sharpened their claims over both. Key opposing groups include national and regional governments, logging entrepreneurs, agro-industrial companies, conservationists and indigenous groups but also rural residents of mixed ancestry and cultural identity. The opposite claims and struggles for control of Amazonia territory and resources frequently becomes violent and led as recently as 2011 to armed clashes between indigenous organizations, police and the army. The contestation over Peru's Amazonian land and resources brings with it that competing parties develop their own discourses and narratives that support their views and claims. The paper analyses competing discourses and narratives as to what should be the future of Peru's Amazon territory, how should resources be developed and who should benefit. The paper will focus on the narratives that actors with interest in Peru's Amazonian forest-development have been expressing over the years, and how these narratives have changed. It will explain these narratives by linking them to the interests of groups and their organizations who develop the narratives or who are the major party in the narrative. The paper will also link the discourses and narratives to the trends of global forest and forest-development discourses. Finally, the paper will reflect on the relevance of forest-development discourse and narrative analysis for the design and implementation of forestry policies and administration.

Forest development; narrative analysis; discourses

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IUFRO17-2427 **A question of method: assessment of bioeconomy and its implications**

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Abstract: Up to now, scientific and political discussions of the term bioeconomy and its various implications have not led to a generally accepted definition. Consequently, criteria and indicators to measure bioeconomy and its impacts are not yet available. To evaluate the current significance and future development of bioeconomy and its contribution to decarbonisation of the economy such criteria and indicators are necessary. The use of wood for material, chemical or energetic utilization already is a major aspect of bioeconomy. For this sector various evaluation methods can be applied and serve as a starting point for bioeconomy assessment. However, the specific methodology of how to measure bioeconomy might have major influence on the outcomes.
The objective of this presentation is to introduce (i) a framework to define possible scopes of bioeconomy assessment and (ii) different methodological concepts on how to measure bioeconomy. Available methods for the forest and wood sector use different official statistics and will be tested for showcase products of the wood-based part of bioeconomy in Germany. The different approaches will be evaluated according to their suitability to measure bioeconomy, to provide indicators for regular monitoring and to estimate the sustainability of the resource base of bioeconomy.

bioeconomy method wood-flow indicator monitoring

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IUFRO17-768 **Haste Makes Waste? Decentralization Reform Failure and Local Defiance in Pingquan County, China**

Xu, T.* (1); Liu, J. (1)

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Abstract: Forest resources are destined to lack a broad and consistent property rights model based on the characteristics of common-property resources. The property rights arrangement of forest resources has been received constant concern and intervention by central, provincial, prefectural governments in China. Since 1980s, Chinese government has implemented two rounds of decentralization reform on forest resources through top-down policies, which aims to clarify the relationship of property rights and regulate forest management and circulation. However, these policies failed in many places due to the rigid nature of the policies and the diversity of local conditions. Forest clearing and elite capture has affected the local village compacts, even aggravated the conflicts of forest rights between the state and collectives. In this paper, four villages were selected to discuss the evolution' process and mechanism of the property rights of forest and woodland resources by using Schlager and Ostrom common-property resources rights analysis framework. The study argues that the decentralization process increased the rights of the rural elite but deprived forest peasants' rights, so the peasants increasingly focus on the ownership of woodland; the state-owned forests not belong to government or any village communities, "officials" of national forest farms are proprietors of them.

decentralization, property rights, tenure reform

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IUFRO17-1186 **Children's books on forestry as a tool to raise awareness about forests**

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Abstract: Sustainable forest management is based on the long-term adaptability of forest ecosystems and their biodiversity which starts at the gene level. As genetic diversity is hidden from the eye, it is necessary to introduce it to different audiences according to their level of understanding and also to present the needs for forest genetic monitoring (FGM) as an early warning system about threats to forests of the future to different publics. One of aims of the project LIFEGENMON is the discussion and dissemination of forestry and FGM issues among different audiences and target stakeholders. Among general public, children of different ages from the kindergarten, primary and secondary school) and their teachers, students and their professors are included. Children's books on forestry were selected as one of the means for presenting, and raising awareness about forest biodiversity and FGM. Three books are to be produced, each for different age group: 4-6 years old children, 1st triad and 2nd triad of primary school. Through a two stage public tender we first concentrated on choosing the appropriate external service providers to cover book production (writing of the story, producing illustrations), cartoons and the development of augmented reality dimension to reach audiences on internet. In the second stage, costs were checked for the final decision. Throughout the production process of the books, experts were involved in editing the texts written in style suitable for children so that it would nevertheless convey relevant information. The first book introduces main characters - Beech Nut, Acorn, twins Cher and Ry, and follows them from city park to Big forest where they meet new friends. In the second book, "Guardians of the forest" face and tackle a threat to spruce forests, the attack of the bark beetles. The third book is yet to be written, but will include characters from first two books and will emphasize care and conservation of forests and the environment.

forestry, LIFEGENMON, forest genetic monitoring

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IUFRO17-3717 **The changes of major ecological factors and its control in the condition of nursery production facilities**

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Abstract: The changes of major ecological factors were observed and surveyed systematically in the greenhouse and cutting stock beds with rotary spray in the Central Nursery.
Research results were given for realizing scientification of nursery production based on it. The period between late February and early March should be assessed as reasonable seeding time according to the analysis on the changes of annual temperature and air humidity in greenhouses with 1000~2000 ㎡ of total area. During the summer, more than 30 degrees C of high temperatures occur in greenhouses, the duration is 2~3 hours per day in May, 4~5 hours in June and 7~9 hours in July and August.
Such a high temperature may drop to 3~10 degrees C down by means of natural aeration and ventilation. Light intensity in greenhouse lies in the range of 57.7~61.5% of full light in the condition of no sunshade, and only 11.5~32.1% when using sunshade inside and outside of greenhouse.
In order to provide nursery with normal growth condition, it is recommended that sunshade should not to be put on inside and outside of the greenhouse. According to the changes of temperature and humidity in greenhouse, it is recommended that seedlings should be raised in greenhouse until late June-early July, and after that the green cuttings should be raised so that greenhouse use efficiency should be improved. And then the tree seedlings should be transplanted onto the field nursery or mountain planting sites.

nursery temperature greenhouse

Poster Exhibition Thursday

54 - Global Forest Technology Sharing Framework

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IUFRO17-1564 **Cyberforest: That is real-time monitoring and archiving a remote forest via Internet for "Sense of Globe"**

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Abstract: We have developed the Cyberforest system that streams and archives live sound and image from remote areas across Japan via an unmanned automatic camera. The system was used at first to carry out pilot bird censuses in woodland, then to environmental education. Those allowed us to examine the use of live sound transmission as a mediator in remote scientific monitoring. We demonstrated that: (1) the transmission of live sound from a remote woodland could be used effectively to monitor birds in a remote location; (2) once one notice the sound of forest on-site, they start to be able to feel close to nature by listening to sounds of natural animals and atmosphere both on-site and off-site; (3) interactions through Social Network Service allowed viewer and listener of the public to engage the remote monitoring of forest and experience inaccessible nature through the use of Cyberforest. Natural places around world can be felt as if we are close-by, since Cyberforest join world-wide sound distribution alliance via open microphones, we can get the intuitive sense of the global environment. Thus, we will get a "Sense of Globe".

Live sound, Cyberforest, Remote monitoring

Poster Exhibition Thursday

166 - Development of Adaptation Strategies for Climate Change using GM Trees

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IUFRO17-678 **The Role of Adaptation Mechanisms in improving livelihood of farmers in Bara locality-North Kordofan State, Sudan**

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(1) University of Kordofan , Elobeid, Sudan

Abstract: This study was conducted in Bara Locality, North Kordofan State during 2013 2015. The objective of the study is to investigate the role of adaptation mechanisms followed by Climate Change Project (CCP). The study considered all villages covered by the project. Purposive sampling technique was used. 106 respondents represent (12%) of sampling frame were selected. Primary data obtained according to scientific methods using well designed questionnaires following face-to-face interview, and focus group discussion. Statistical Package for Social Sciences (SPSS) version 10 was applied for analyzing the data and obtaining the results of concern using descriptive statistic and Chi-squire Test. Results of descriptive statistics revealed that 53.8% of the respondents declared that the project had obvious contribution in horticulture, while 61.3% indicated that the project had positive role in improving water resources, 98.6% of the respondents depicted that provision of alternative energy sources had strong contribution in environmental conservation. On the other hand results of Chi-squire showed significant differences among the respondents regarding to mechanisms adopted by the project comparing the pre-project period regarding the activities: traditional farming, horticulture, and rage and forestry. Many recommendations were drawn from the study among them; dissemination of alternative energy sources is highly encourage due to their positive role on environmental conservation and make use of solar energy in horticulture.

; Adaptation, Mechanisms, Climate Change, Sudan

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IUFRO17-2925 **Variation of non-target wood properties of multi-gene transgenic Poplar (Populus × euramericana 'Guariento')**

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(1) Research Institute of Forestry, Chinese Academy of Forestry, Beijing, China; (2) Shandong Academy of Forestry, Jinan, China

Abstract: In this study, in order to understand whether the transgenic of exogenous genes produce unintended effects on plant phenotypes, 5-year-old trees of the transgenic poplar (Populus × euramericana 'Guariento') harboring five exogenous genes (SacB, vgb, BtCry3A, OC-I and JERF36) and the control plants were compared with respect to variation of wood properties. The results showed that the transgenic of exogenous genes caused a wide range of variation in non-target wood properties. The variations were found not only between transgenic and wild-type lines, but also among transgenic lines. Compared with the control, transgenic lines displayed increased contents of holocellulose and cellulose, and decreased contents of the total lignin and acid soluble lignin. Other properties including fiber length, fiber width, microfibril angle and acid insoluble lignin were also varied uncertainly. It is concluded that the introduced exogenous gene could generate unintended effects on corresponding non-target traits.

poplar; wood properties; non-target traits

Poster Exhibition Thursday

68 - Forest Adaptation and Restoration under Global Change

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4133 **Ecotypic variation in response to light spectra in Scots pine (Pinus sylvestris L.)**

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Abstract: In addition to the temporal (diurnal and seasonal) fluctuations, the light spectra also show spatial (latitudinal, longitudinal and altitudinal) trends. Across the latitudes, the twilight zone increases in duration especially during the growing season) and far-red content northwards, while blue content is depleted northwards. Adaptation in forest trees to temporal and spatial variations in the photoperiod and light spectra has resulted in steep adaptive clines. A number of investigations have described the ecotypes related to photoperiod and light spectra in forest trees.

Analysis of variance revealed a northward decrease in the inhibitory effect of FR with respect to D, the so-called far red high irradiance response. Ecotypic variation for hypocotyl development was observed under the FR and D treatments, while the trends for the B and R treatments were not statistically significant. Under FR the ecotypic variation showed an increase in hypocotyl length northwards, in contrast to the treatment under D which showed a decrease in the hypocotyl length northwards. These results could be interpreted in view of the previously reported northward increase in FR requirement to maintain growth in Norway spruce and Scots pine. Prior to the performance of the main light experiment, the maternal effect on progeny performance was investigated, which showed the absence of maternal environment effect on the performance of the seedlings.

light spectra, ecotype, Scots pine

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IUFRO17-1804 **Intra-specific plasticity of seasonal dynamics of xylem formation and vessel features in European beech**

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Abstract: To evaluate how beech adjusts xylem structure to changing environmental conditions the dynamic of xylem differentiation processes as well as vessel characteristics were investigated. Analyses were performed on micro-cores collected at weekly intervals at two forest sites, Menina planina (1200 m a.s.l.) and Panska reka (400 m a.s.l.) between 2008-2011 growth seasons. Time intervals between the onset and end of major xylem cell differentiation steps and vessel characteristics (i.e. vessel density - VD, mean vessel area - MSV, and total conductivity area - WCA) were analysed in the first and last quarters of the xylem rings, also in respect to the local weather conditions.
Results showed that although onset, duration and end of xylem formation phases differed between the two sites, and being generally longer at low elevation site PA, the time differences between successive wood formation phases were similar. Significant differences in MSV and WCA values were found between the first and last quarters of xylem increment irrespective of the site and year. Contrary, VD was significantly higher in beech from high elevation site with narrower xylem rings.
VD was the only vessel characteristics that significantly differed between sites; it was influenced by maximum mean temperature. VD can thus be used as a sensitive climatic proxy at the selected temperate sites.

F. sylvatica, wood, conductivity, weather

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1642 **Results of Douglas fir provenance tests in Bavaria (Germany) established 1970 to 1985**

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Abstract: The distribution of Douglas fir expands farther outside its natural range than most other American forest tree species. In Germany and Bavaria it has been planted for over 100 years and is the most important non-native tree species. Douglas fir is an accepted part of forest management because of its economic importance and its reputation as a species that may cope well with climate change, especially due to its drought resistance. The Bavarian Forest Administration decided to participate in the IUFRO International Douglas Fir Provenance Study at the beginning of the seventies last century. As a consequence, the ASP established 2 IUFRO- and 13 national trial sites with 119 provenances in different growing areas of Bavaria.
The trials in Bavaria show general superiority of the coastal variety compared with the interior variety (nothern and southern subvariety). Provenances from Washington coastal range, Olympic Peninsula and the western slope of the Washington Cascades convince with best height growth and good vitality. At the age of 40 some provenances reached heights above 30 m and can be recommended for the cultivation in Bavaria. Test populations from Vancouver Island, from the Coastal Area south of British Columbia and from the northern coastal range in Oregon have also results above average. On the other hand, provenances from the northern Rocky Mountains in British Columbia (northern subvariety) could not convince even on trial sites with cooler climate (e.g. eastern low mountain range).
The excellent performance of some populations shows a very high growth potential of Douglas fir in southern Germany and illustrates its future importance for cultivation under climate Change.

Douglas fir, provenance, climate change, Germany

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68 - Forest Adaptation and Restoration under Global Change

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IUFRO17-2140 **Survival strategies of quercus pubescens willd. From Slovenian sub-mediterranean region to different soil water availability**

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(1) Slovenian Forestry Institute, Ljubljana, Slovenia; (2) Biotechnical Faculty, Ljubljana, Slovenia

Abstract: In Central Europe, it is expected that a changing climate will increase the frequency and severity of drought events. Among all European regions, the Mediterranean appears to be the most vulnerable to climate change. In Slovenia, pubescent oak (Quercus pubescens Willd.) is one of the dominant native tree species in Karst region and is ecologically important as it is growing in forests that prevent degradation of vulnerable, shallow and erosion-prone soil. Despite its importance, information about its growth patterns in Slovenian Sub-Mediterranean is lacking. In the study, we monitored intra-annual xylem and phloem formation in combination with leaf development and xylem sap flow measurements. For this purpose, in two growing seasons of 2015 and 2016, two research plots that differ in water availability (limestone and flysch bedrock) were selected. We found that seasonal dynamics of wood formation can be linked with seasonal patterns of xylem sap flow, that is also well correlated with leaf phenology in early spring. Xylem and phloem growth patterns differ between the two sites; trees with higher water availability had wider annual increments. Preliminary results confirm that soil water availability is closely related to radial growth of pubescent oak.

pubescent oak, climate, sap flow, anatomy, Karst

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IUFRO17-3913 **Soil preparation method impact on Norway spruce and Scots pine containerised seedling root system development**

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(1) LSFRI Silava, Salaspils, Latvia

Abstract: Soil preparation is a common practice that precedes outplanting of Norway spruce (*Picea abies*) and Scots Pine (*Pinus sylvestris*) as it has been proven to enhance the survival and early growth of seedlings in Fennoscandinavia. Nonetheless the combined effects of forest type and soil preparation have not been looked at within Latvia. Containerized P. abies and *P. sylvestris* seedlings were excavated 1-3 years after outplanting in clear cut forests across Latvia. The excavated seedlings were grown in *Myrtillosa turf. mel., Mercurialosa mel., Myrtillosa mel., Vacciniosa mel., Myrtilloso-sphagnosa, Vaccinioso-sphagnosa* type forests that had been prepared either using site mounding or disc trenching soil preparation methods. The aim was to determine the combined effects of soil preparation and forest type on the development of seedling roots. Seedlings were measured, excavated during the summer of 2016 and divided into above and below ground parts that were then oven dried. A comparison of dry weight proportions revealed that *P. abies* root weight proportion was largest for seedlings growing on spot mounded sites in *Vaccinioso-sphagnosa, Myrtilloso-sphagnosa.* In the case of P. silvestrys however best results were obtained from seedlings grown on disc trenched sites in *Mercurialosa mel., Myrtillosa mel., Vacciniosa mel.* type forests. Development, deep and location of main roots were fixed. Both species grown on mound have a deeper and symmetrically placed roots, while in furrows made by disc trencher roots were located parallely to furrow direction. Two sided root system located perpendicularly to main wind direction could help to increase the stability of forest stand. No correlation between roots growing direction and cardinal points were found.

scarification, mounding, Root developmen

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1012 **Population characteristics and seed quality of two distinctive Saxaul (Haloxylon ammodendron C.A. Mey Bunge) stands from Mongolia**

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Abstract: Mongolia is one of the countries severely affected by desertification and land degradation. Haloxylon ammodendron C.A. Mey Bunge is an important component of the desert ecosystem distributing in the south of Mongolia and is one of the main shrub species used for restoration. We conducted comparative research in two populations of H. ammodendron distributed in Eastern (Dornogobi) and Southern (Umnugobi) Mongolia. We assessed their survivorship and mortality and seed quality traits. Studied populations were dominated by juvenile and adult individuals and natural regeneration was extremely limitedon both populations. Tree size distributions were skewed towards larger size classes and survivorship curve showed the higher mortality in the early life stages and stabilized in later stages. 1000-seed weight was 3.5 gr (Dornogobi) and 2.8 gr (Umnugobi) province. Higher germination energy (GE) was observed in Umnugobi province (84.4 ±1.2%) than that of Dornogobi (63.5±1.5%). In terms of seed size, large seeds tend to have more higher germination compared with small and medium sized seeds. These results suggest that studied populations of are threatened and efforts are required to minimize uncontrolled exploitation and overgrazing. Limited seedling recruitment requires conservation efforts in order to protect existing populations in both provinces.

Saxaul, population, seed quality, Mongolia

Poster Exhibition Thursday

68 - Forest Adaptation and Restoration under Global Change

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2203 **Adaptation of old Scots pine stands to local ecosystems. Research based on genetic markers and seeds characteristics.**

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Abstract: Evolutionary processes lead to the consolidation of the best adapted individuals in local ecological conditions. In the context of the currently observed climate changes and accelerating selection processes, the criterion of adaptation gains special importance. Selection pressure is effectively visualised by changes in the frequency of alleles in relation to the expected values, in accordance with the Hardy-Weinberg equilibrium. However, the reproductive potential of a given population can be determined based on its ability to produce live and effectively germinating seeds. The presented results are a combination of molecular analyses with anatomical and morphological studies of Scots pine seeds (Pinus sylvestris L.). On their basis it was proved that there is a negative correlation of energy and germination capacity with the values of genetic variation parameters: effective number of alleles per locus, observed heterozygosity and the Shannon index. It was also proven that there is a significant correlation between the performance of seeds from cones and the number of seeds in one cone with the geographical location of the population. In addition, cline variation was proved at locus Gdh-A. The obtained results indicate that there are selection processes that locally affect the analysed populations.

genetic marker, Scots pine, adaptive capacity.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1214 **Daily and seasonal activity of Fagus sylvatica and Acer pseudoplatanus according to tree conductivity**

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Abstract: Phenology has a major impact on the fitness and distribution of tree species. Currently, global warming is modifying the phenology of temperate trees, particularly during the onset of spring, in Europe. Changes in phenology may even affect climate. Over the last two decades, there has been a renewed interest in the overall impact of phenological shifts in forest ecosystems due to climate change (Vitasse, Lenz & Körner 2014) but gathering phenological data is very arduous. The Department of Forest Sites and Ecology (Poznan University of Life Sciences, Faculty of Forestry) has constructed a set of sensors which automatically register tree conductivity, humidity and temperature at an assumed time interval and has placed the sensors in beech and maple tree stands. The results obtained after one vegetation season show the differences between the daily and seasonal activity of Fagus sylvatica and Acer pseudoplatanus, helping to develop an understanding of the environmental factors driving tree phenology

Fagus, Acer, conductivity, phenology

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3213 **Turkish hazel in Bulgaria-an autochthonous and valuable tree species for the climate change**

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Abstract: Climate change will affect all forest ecosystems and goods that forests provide. A possible suitable adaptation strategy to stabilize instable forest stands is given through building mixed forests. By supplementing the existing spectrum of tree species in Central Europe, the risk can be minimized. The origin of the reproductive material of a tree species has a central role for the adaption and the possibility of their cultivation.
A tree species that is currently being discussed as a valuable alternative in Europe and occurs naturally in Bulgaria is the Turkish hazel (Corylus colurna L.). However, this tree species is actually rarely used in Bulgaria and has fallen into oblivion in the forest sector. The Turkish hazel is distinguished by valuable wood and was therefore overused in most of the countries of origin. Presently only a few isolated and very small populations are found. As a result, the remaining Turkish hazel seed stands in Bulgaria are of enormous importance and can be used as a natural reservoir for seed production. These populations are already well adapted to the environmental conditions of Bulgaria.
The aim of the project is to test and describe different Bulgarian provenances in different climatic and soil conditions and assess the possibility of their cultivation. The required propagation material does not need to be imported from other countries and the plant material can be grown in the local forest tree nurseries.
In addition, seeds can be sold to other European countries (e.g. Germany, France, Austria), where the demand of Turkish hazel is increasingly due the tolerance to frost and drought.

Adaptation, provenances, climatic/soil conditions

Poster Exhibition Thursday

68 - Forest Adaptation and Restoration under Global Change

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1120 **Forestry Institutions and their role in reducing vulnerability, and build resilience in the age of climate change in Nepal**

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Abstract: Wide range forestry institutions mainly the form of community based forest user groups are growing and contributing in the management of forest resources, and at the same time supporting to enhance socio-ecological resilience in the face of climate change. About 23% of the total populations in Nepal live below poverty (less than 1.25USD/day) and the country is ranked one of the 4th climate vulnerable country around the world. Nepal exhibits a wide ranging climatic conditions varying from tropical in the south to alpine/arctic in the north. Flash floods and landslides, loss of biodiversity and decrease the availability of medicinal and aromatic plants, decline in agricultural productivity, and increase of invasive species and depletion of fresh water resources are some major vulnerability resulted from the impact of climate change. These adversities resulted from the impact of climate change are making the lives and livelihoods of over 1.9 million people vulnerable, and putting 10 million people at risk.

Responding to these climates induced adversities, the local communities that are organized in the form of forest user groups have started making their adaptation plans (more than 2500 plans) in order to adapt and build socio-ecological as well as economic resilience in partnership with both government and non-government institutions. The analysis of about 500 local adaptation plans of the total 2500 plans have brought the insightful reflection in relation to institutional and financing capacities to respond the major vulnerabilities identified in different adaptation plans and local practices of responding these vulnerabilities at different level and scale for building socio-ecological resilience in Nepal.

Community, Resilience, livelihood, Adaptation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3177 **The current distribution and the role of black locust (Robinia pseudoacacia L.) in Poland**

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(1) Forest Research Institute, Raszyn, Poland

Abstract: Black locust has been present in Poland for more than 200 years, its range coming to encompass nearly the entire country. Overall, it is present in 3.4% of the stands and is dominant species in 0.1% of them. Low intensive breeding recently concentrates on selection of new stands in which trees have particularly straight trunks.
The growth of 10 black locust provenances from Poland and Hungary was analysed on 3 experimental trials with different site conditions. Species is also examined on the other 2 experimental energy plantations in terms of spacing and various clones. The first results shown significant differences among provenances in growth and heritability. The Hungarian commercial material "Turbo" performs about 30% better than Polish seed sources.
Black locust wood has a great specific gravity and calorific value as well as low moisture content and is suitable to combust even when wet. In Poland nearly 100 000 m3 per year of locust timber is harvested and 50% of it is used for energy purpose. Black locust is regarded as an undesirable alien nonetheless plays important role also as bee forage, leading to the production of high-quality honey. In terms of the nectar content and generate honey in hives, the species is second only to lime.

distribution, plantation, breeding, timber, honey

Poster Exhibition Thursday

111 - Today ignored, rediscovered tomorrow: The importance of minor tree species in future.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1908 **Growth and gas exchange of seedlings and root sprouts of minor European broadleaved tree species under drought conditions**

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(1) Institute of Forest Sciences, Chair of Silviculture, Freiburg, Germany

Abstract: Economically important and widespread European tree species such as spruce, pine, and beech are projected to be negatively affected by dry and hot conditions in a future climate. Hence, there is an increasing need to investigate the suitability of presumably more drought tolerant species to ensure future ecological stability, biodiversity, and productivity of forests. Based on their distribution patterns the minor broadleaved tree species *Acer campestre*, *A. platanoides*, *Sorbus torminalis*, and *S. domestica* are assumed to be drought tolerant. However, there is only limited experimental basis to support that notion.
This study aimed at quantifying growth and gas exchange of seedlings and root sprouts of these species during drought conditions. For that purpose, they were compared to the common companion species *Quercus petraea* and *Fagus sylvatica*. Here, potted seedlings of the four minor broadleaves were exposed to water limitation followed by rewetting cycles in a greenhouse experiment. Furthermore, seedlings of *A. platanoides* and root sprouts of *S. torminalis* were exposed to an artificial drought experiment under field conditions. In the greenhouse experiment, photosynthesis and transpiration rates, stomatal conductance as well as root and shoot growth rates indicated a high drought resistance of both *Acer* species; *S. domestica* showed a marked ability to recover after drought stress. In the field experiment, the very conservative water consumption of *A. platanoides* was a key factor to withstand drought.
Therefore, we conclude that these minor tree species have the potential to enrich forests on drought-prone sites.

minor tree species, Acer, Sorbus, drought tolerant

Poster Exhibition Thursday

184 - Marketing and Business Practices of the Bioeconomy

KG II - HS 2121 (Uni Freiburg)

IUFRO17-194 **Importance of the use harvested wood products in objective of neutralization of carbon emissions by residential building construction in Brazil**

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Abstract: Within the context of global warming, the evolution of agreements in conferences between the parties (COP) directs the nations to produce emissions reporting greenhouse gases (GHG) more precisely. This puts for industries the importance to account more accurately their GHG emissions. For Brazil, a country which is great producer of wood, to sectors of forest and construction industries is relevant to consider the carbon stored in harvested wood products that are used in buildings. This accounting provides a better precision in quantifying GHG emissions by the construction industry and promotes the forestry sector, showing that this one is an important part in the way of greenhouse problem solution. This work studied usual wood products in Brazil as doors, floors and ceilings, made from certified wood, which were applied in five projects of residential apartments with different patterns and sizes in Sao Paulo (Brazil). For these apartments the construction company published GHG emissions by its construction without considering the carbon stored in wood products. The study shows that the stored carbon neutralizes the order of 10% of the CO2 emitted by its construction.

Carbon emissions, harvested wood products

Poster Exhibition Thursday

58 - Managing forests for Biodiversity and Resilience

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2580 **Composition of vegetation on skid trails with different treatment strategies in the experimental forest area in Merklingen, Germany**

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Abstract: In forest ecosystems ground based skidding leads to soil compaction which disturbs soil structure and modifies both physical and chemical microclimate. This affects the plant community above and below-ground. Sustainable management may require active soil restoration measures where the natural regeneration of damaged soils may take from several years to decades.
In a wheeling experiment site in Merklingen, SW Germany, three skid trail sections were treated in 2012 by application of dolomite lime, mulching, a lime-mulch combination, a fourth section was left untreated. Active planting of select, well-adapted tree species like Alnus sp. was also employed. Two years after the compaction event the ground vegetation (<2 m) was mapped in 90 plots of 50x50 cm across the skid trails and in two random 5x5 m control blocks. Plant cover was classified according to Braun-Blanquet. Soil samples were extracted with Eijkelkamp augers at 0-15 cm depth and pH, TN, plant available NO3- and CEC were measured and compared with Ellenberg's plant indicator values.
All four treatment types showed great diversity in their ground vegetation cover, richness and species composition, which was also impacted by the planting of Alnus sp. The effects of soil compaction were visible in the plant community.

Soil compaction, Lime, Mulch, Alder, Vegetation

Poster Exhibition Thursday

72 - Oak forests and management for different ecosystem services

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3301 **Silviculture of mixed oak stands can be supported by natural succession processes**

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Abstract: While in Central Europe far-from-nature monocultures were under high interest in the past, at the present time close-to-nature mixed forests are in advance. Here, we present the model for silviculture of mixed oak stands by means of natural succession processes by contrasting it with the common used in forest practice model which assumes development of oak excluding tree species admixtures within the same storey. We compare the selected growth parameters of oaks (mean diameter, height, slenderness), as well as the whole stand level productivity and structural diversity between both models at the three developmental stages. Thus we use three data sources. The first set of data consists of results of two inventories performed on 130 plots located in 13 mixed and pure oak young growths. The second data set bases on the detailed survey conducted on 2 plots (0.25 ha, each) in stands representing respectively two silvicultural models at the pole stage. The last data set includes data from 20 sample plots (0.25 ha, each) established in mature (80-90 years old) mixed and pure oak stands. All plots were established in eastern Poland and thus represent the conditions of continental climate. The oak mixed-species stands consisting of early successional tree species (birch, aspen, pine) are characterized by a more diverse and balanced tree species composition and a greater vertical structural differentiation than the oak stands treated by classical model. The oaks that were growing under the influence of early successional tree species, were just a bit thinner, smaller and more slender at the same age than the oaks treated according to the traditional model. However, the latter ones are characterized by a slightly better technical quality. The results obtained point out the great possibilities for use natural succession processes to optimize the silviculture of mixed oak stands, i.e. lower the costs of silvicultural treatments by biological rationalization.

forest succession, oak mixed stands dynamics

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1654 **Stand structure, vegetation, and regeneration of the semi-natural deciduous mixed oak forests in the Western Qinling Mountains, China**

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(1) Chunling Dai, TÜV NORD CERT GmbH, Beijing, China; (2) Albert-Ludwigs Universität Freiburg, Freiburg im Breisgau, Germany

Abstract: Qinling Mountain is a home of diverse oak forests (e.g. 11 species of oaks). However, oak forests were highly degraded by past human activities. Enriching ecological knowledge of oak forests from species to community level is trivial to restoring these forests. However, field studies on phytosociology, forest structure and natural regeneration of main oak species are still very rare. A forest inventory was carried out on systematically selected 120 inventory plots (plot size: 400 to 450 m ²) in semi-natural oak forests stands in the montane zone protected since 1998. A total of 448 species of vascular plants (56 tree species) were identified. Seven different forest types were defined reflecting high floristic Beta-diversity. The stand basal area and the tree diameter distribution showed highest frequency of young trees denoting the recovery of forests after protection. A gap experiment study combined with hemispherical photo analyses showed that the regeneration of a most common oak species Quercus aliena var. acutiserrata, was not influenced in a gradient of solar radiation transmittance. We reported first time that this species can tolerate some degree of shade. We concluded that protection from human disturbances should be continued to develop well-stocked semi-natural mixed oak forests of native species.

Oak Vegetation Stand-Structure Regeneration Light

KG II - HS 2121 (Uni Freiburg)

IUFRO17-991 **Stand density assessment in cork oak woodlands - a diagnosis of the Portuguese forest systems sustainability**

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Abstract: Cork oak (Quercus suber) is a valued oak species providing key ecosystems services and goods managed as both a pure forest for cork production as well as agroforestry or silvopastoral areas. It ranks first in extension in the class of autochthonous species of the Portuguese forest, with an occupancy of 737 thousand hectares (23 % of the mainland forest area). Both management types are present in the country with the former systems being more common in the North region of Portugal and the silvoagropastoral systems being predominant in the Centre and the South regions. The results of the NFI 6 point out for a maintenance of the area occupied by the species in the period 1995-2010. In counterpart, in terms of the stand density, research findings denote an increasing reduction of crown cover and a suboptimal occupancy of the stands these being associated with forest degradation and /or to inadequate forest practices. Increasing demands for cork as a raw material for the industry has been putting stress on the need of maximizing the crown cover, hence assuring for a sustained supply. This research aims to assess for the current state of the cork oak woodlands using the data of the NFI and to provide silvicultural guidelines that allow to assure medium and long term sustainability.

ecosystem services, productivity, sustainable use

Poster Exhibition Thursday

72 - Oak forests and management for different ecosystem services

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1656 **Proposals for the improvement of genetic seed quality in approved oak seed stands**

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(1) Northwest German Forest Research Institute, Hann. Münden, Germany

Abstract: In the course of forest conversion and climate change pedunculate and sessile oak are considered to be of high ecological importance in German forestry. While the domestic demand for timber increases, forest areas are taken out of production. Hence, the need for high quality forest reproductive material with the potential to increase productivity and timber quality of future stands will increase.

There is evidence that a phenotypic selection of parent trees will entail genetic effects and increase the proportion of requested traits in the progeny. The regulations for forest reproductive material are generally based on this principle.

As a short-term possibility to provide seed of superior genetic quality it is suggested to restrict seed harvesting not only to selected seed stands but to phenotypically excellent single trees within theses stands. The genetic quality can be improved additionally by specific silvicultural measures.

The present paper evaluates the possibilities for a single tree based seed concept. 5 existing seed stands are analyzed in detail and used for simulations of different harvesting and silvicultural variants. Data on registered seed stands and on seed quantities harvested during the last decade show that there is sufficient potential for realizing a concept of selective seed harvesting.

oak, seed, seed stand, genetic quality

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3445 **Shrubs protect oaks against ungulate browsing in temperate broadleaved forests of conservation interest: A long-term experiment**

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Abstract: In many temperate broadleaved forests, oak regeneration is restricted by a high ungulate browsing pressure. Neighboring woody understory has been shown to reduce browsing risk. However, it is still uncertain if this facilitative effect also provides long-term protection. We test this in a long-term field experiment. In 2007, we planted oak seedlings (Quercus robur) in four different treatments in ten forests across southern Sweden; two with shrubs and two without shrubs. Moose and deer were excluded from two treatments at each site, one with and one without shrubs. We have then monitored survival, growth and browsing risk over a period of nine years. Focusing on browsing risk, our initial measurements - done three years after planting - showed that shrubs did offer protection from browsing: the risk of browsing was 20 percentage points lower for oaks planted in shrubs. However, nine years after the initial planting of the seedlings, this advantage had decreased substantially. At this point, oaks planted in shrubs only enjoyed a percentage points lower risk of browsing. While this difference in risk between the shrub/no shrub treatments is still statistically significant, we conclude that the initial effect of protecting oaks from browsing has decreased substantially over time.

Neighboring effect; Forest restoration

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2536 **Management of oak forests: striking a balance between timber production, biodiversity and cultural services**

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(1) Swedish University of Agricultural Sciences, Alnarp, Sweden

Abstract: The understanding of the ecosystem services provided by oak-dominated forests is a prerequisite for ensuring their sustainable management. Various types of oak forests in southern Sweden seem well-suited for multiple-use forestry, but we do not know how to manage them for multiple uses. Management of oak forests for the production of high-value timber, to conserve biodiversity or management for cultural services can be in conflict with each other. The aim of this study was to evaluate the capacity of three contrasting management regimes to provide economic revenue from timber production, habitats for biodiversity and cultural services, and we analyse trade-offs and synergies. The three management regimes in oak forests were: intensive oak timber production (A), combined management for both timber production and biodiversity (B) and biodiversity conservation without management intervention (C). To analyse this we synthesized relevant literature. Our assessments identified that Regime A provided most timber production and the highest levels of economic returns but the lowest level of biodiversity. Regime C provided higher levels of habitat provision for biodiversity but at expense of wood production and cultural services. On the other hand, Regime B provided a balanced delivery of timber production, biodiversity conservation and cultural services. We also identified several stand-management options which provide comparatively synergistic outcomes in ecosystem services delivery. The use of these options in combination with more traditional management approaches may be a more effective means of achieving sustainable forest management in oak-dominated forests.

multiple-use, silviculture, trade-offs

Poster Exhibition Thursday

72 - Oak forests and management for different ecosystem services

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1501 **Silviculture of sessile oak (Quercus petraea)-dominated stands in Romania: stand or single-tree oriented?**

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(1) University Transylvania of Brasov, Brasov, Romania

Abstract: Sessile oak (Quercus petraea) is the dominant oak species in Romanian forests and its silvicultural management targets the production of high-quality wood for end-uses such as veneer, solid furniture, flooring, lumber, etc.
The sessile oak-dominated stands in Romania are managed classically (stand silviculture), using low intensity and mixed (from below and from above) interventions. Consequently, the production of large-diameter logs, at rotations usually longer than 120 years, when the stocking is 300-400 trees/ha, is targeted.
As there is a high interest in reducing the early management costs and rotation age of top-quality and large-diameter sessile oak trees, a large-scale project established in sessile oak-dominated stands of Forest Districts (FD) Valea Mare and "Stejarul" Rupea, comparing classical (stand) silviculture vs. dynamic (single tree-oriented) silviculture was launched 15 years ago.
The large-scale application of dynamic (single tree-oriented) silviculture was more effective in both technical and economic terms, as the (potential) final crop sessile oak trees favored by interventions targeting their free-growth state at crown level show a higher diameter and crown increment. The occurrence of epicormic shoots, a potential drawback of this silvicultural option, was encountered only on slender sessile oak trees with small and unbalanced crowns.

sessile oak, stand, single-tree silviculture

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2211 **Visual assessment of naturally grown Japanese oak trees for whisky barrels**

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Abstract: The demand for domestic Japanese oak (Quercus crispula Blume) timber increases as material for whisky barrels. Large-diameter and high-quality oak trees which grow naturally can only be utilized for barrel staves, while such superior trees rarely occur and are sparsely distributed over mixed conifer-hardwood forests in Hokkaido, northern Japan. Operationally, lumber engineers observe the trunk of candidate oak trees visually to assess the yield of barrel materials, based on their empirical skills and knowledge gained through the long-term work experiences. Little is explicitly known on how visual trunk assessment of standing oak trees is actually made by experienced lumber engineers. The purpose of this study was to capture the expert knowledge of visual assessment practices for whisky barrel materials. A case study was conducted in April and October 2015 at the University of Tokyo Hokkaido Forest. 31 candidate oak trees were assessed by forest technicians and sawmill engineers. Although sawmill engineers tended to strictly assess defects in tree trunks compared to forest technicians, both occupations evaluated a higher yield of barrel materials from trees with no twisting and taller trunk height. A tracing survey was also conducted at the sawmill to examine the actual yield of barrel staves.

Japanese oak, visual assessment, whisky barrel

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2245 **Net primary production of an oak-dominated evergreen broadleaved forest in warm-temperate region of Japan**

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Abstract: Carbon uptake is an important ecological service provided by forests, the extent of which could vary depending on the biomes present, dominant species, and forest age. In warm-temperate regions under the East-Asian monsoon climate, oak-dominated evergreen broadleaved forests are the potential and naturally dominant vegetation. The objective of this study was to estimate the net primary production (NPP) of an 80-year old evergreen oak forest in Japan using biometric approaches. Evergreen oak species (*Quercus* and *Castanopsis*) accounted for half of the total basal area of the studied forest. Increment of the basal area, litter fall, root growth, and coarse wood debris were measured in a 1 ha plot over two years beginning from 2005. As a result, the NPP was 10.9 and 12.6 MgC ha^{-1} y^{-1} for the first year and the second year, respectively. The variation in the NPP between the two years was mainly due the difference in coarse wood debris production. This indicates that NPP of the evergreen oak forest will be susceptible to factors affecting coarse wood debris, such as climate disturbance and successional tree replacement.

NPP, evergreen broadleaved forest, Japan

Poster Exhibition Thursday

72 - Oak forests and management for different ecosystem services

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3325 **Study on the characteristics of sprouts growh for oak forest in South Korea.**

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Abstract: Oak forests, natural dominant species in Korea, have been used as energy for house because of good sprout ability. In recent years, the demands of small log are increasing for Shiitake mushroom (Lentinus edodes) log and charcoal rather than firewood. It is necessary to find ways for various utilizations of oaks using small and middle diameter logs. This study was conducted to improve the tending system for oak forests in order to meet various demands. The sprout occurrences and growth patterns according to the stump conditions were investigated for oak (Quercus mongolica and Q. variablis) forests which felled five years ago. Sprout production was found to be high under the following conditions; when the stump diameter size was less than 10 cm, the stump height was low, and when it was Q. mongolica than Q. variablis. Most of sprouting had 1 cm ~ 3 cm diameters below 10 cm in the stump diameter and had 2 cm ~ 4 cm diameters from 10 cm to 20 cm in the stump diameter. The diameter size of sprouting tended to increase as the stump size increased. The height of sprouting also tended to increase as the stump size increased. However there was no statistically significant relationship between the stump height and the sprouting height.

oak, sprouts, traditional coppic

Poster Exhibition Thursday

206 - Operational methods for monitoring and assessment of forested landscapes

KG II - HS 2121 (Uni Freiburg)

IUFRO17-674 **Spatial model to detect stingless bees sites**

Victorino Nicolosi Arena, M.* (1); Hartung Toppa, R. (1); Cristina Mathias da Silva Zacarin, E. (1); Camacho Destefani, F. (1); Nunes, T. (1); César da Silva Mascotti, J. (1); Rodrigues de Oliveira Pires, V. (1)

(1) UFSCar, Sorocaba, Brazil

Abstract: Stingless bees are among the main pollinators of the most important economic agricultural cultures all over the world, however many populations are declining due especially to habitat loss and land use intensification. The landscape composition plays a key role in determining richness and abundance of bee species, and different groups of bees may show divergent responses according to the land use. Several landscape factors may also be responsible for the environment response on pollinators, as urbanization and area of forest fragments. Using map algebra associated with GIS, this research aims to develop a model to identify landscape factors that are essential to detect and conserve stingless bees, from tribe Meliponini, that are more sensitive to urbanization and fragmentation effects, and that nest in pre-existing cavities, like hollow trees. The research was conducted in Brazilian Atlantic Forest fragmented forests. By the end of this research, it will be possible to correlate the studied landscape factors to the characteristics of the group sampled in nature to validate the model in order to identify the best conservation strategies to native stingless bees.

map algebra, Meliponini, landscape, fragmentation

Poster Exhibition Thursday

84 - Promoting forest resilience, adaptive capacity, and ecosystem services through diverse forest

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3442 **Managing boreal forest structural diversity under global change risks : resistance or resilience, or both?**

Kuuluvainen, T.* (1)

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Abstract: Boreal countries are rich in forest resources, and compared to their area they produce a disproportionally large share of the lumber, pulp, and paper for the global market. These countries have long-standing traditions in forestry education and institutions. Forest management is based on plantation-type, short-rotation and low-retention approaches, emphasizing timber output. This is strived for by pre-commercial thinning and minimising losses due to natural disturbances. This management system creates forest landscapes composed of mosaics of young, even-aged stands with low structural diversity characterized by scarcity of old and dead trees. In contrast, unmanaged landscapes are characterized by high structural diversity characterized by uneven-aged stand structures, continuous presence of old and large trees, and abundant dead wood. The large scale simplification of boreal forest ecosystem structures has already resulted in declining biodiversity. This combined with rapidly changing climatic conditions, pose new risks to the long-term maintenance of biodiversity and provisioning of important ecosystem goods and services. To confront these risks, there is a need for ecosystem management approaches promoting a transition from plantation-type forestry towards more diversified management approaches enhancing both resistance and resilience of forest ecosystems.

Climate change, trait diversity, adaptive capasity

KG II - HS 2121 (Uni Freiburg)

IUFRO17-905 **The influence of nutrient availability on the relationship between tree diversity and aboveground productivity in juvenile tree communities**

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Abstract: Many studies have shown that biomass productivity increases in tree mixtures compared with monocultures. This overyielding has been explained by complementary interactions between tree species. However, few studies have addressed how the magnitude of the underlying mechanisms varies with environmental factors, e.g. soil fertility. In this context, our study aims to examine the relationships between tree diversity and aboveground productivity along gradients in nutrient availability established through fertilizer applications. Here we present results from a young tree diversity experiment established in 2013 at Freiburg, Germany, within the International Diversity Experiment Network with Trees (IDENT). Tree seedlings of 6 European species were planted at high density in monocultures, 6 combinations of two-species mixtures and 6 combinations of four-species mixtures. Each plot-based community has both fertilized and unfertilized plots, each of which were replicated four times. Through comparison of aboveground biomass between different treatments, our research will address the following concrete questions: 1) what metric of diversity (e.g., species richness or functional diversity) is a better predictor of productivity regardless of nutrient availability; 2) how does nutrient addition affect complementary interactions in mixtures.

Tree Diversity,Overyielding,Nutrient Availability

Poster Exhibition Thursday

123 - Roots and Ecosystem Services

KG II - HS 2121 (Uni Freiburg)

IUFRO17-468 **Fine root production and turnover of Pinus massoniana plantation in Zigui ,China**

Cheng, R.* (1); Xiao, W. (1)

(1) Institute of Forest Ecology, Environment and Protection,, Chinese Academy of Forestry, Beijing, China

Abstract: Sequential soil coring and buried bag were used to measure the fine root production and turnover of 20 year-old Pinus massoniana plantation in Zigui, China, from March to December, 2014. The results indicated that the annually mean biomass of fine root ,whose diameter was less than 2mm, was 156.89g·m-2, among which the living root biomass was greatly more than that of dead root. The seasonal variation of fine root biomass, whose diameter was less than 1mm, was more evident than that of the root, whose diameter was between 1mm and 2mm. Fine root annual production and turnover rate were 105.21g ·m-2y-1 and 1.06y-1, in which, the annual production of two diameter classes were 57.24g·m-2y-1, 44.65g·m-2y-1, respectively. The turnover rate of fine root ,whose diameter was less than 1mm, was larger than that of root, whose diameter was between 1mm and 2mm, 1.3 y-1 and 0.63y-1, respectively .

Pinus Massoniana , fine root production, turnover

KG II - HS 2121 (Uni Freiburg)

IUFRO17-469 **Fine root decomposition and nutrient release of Pinus Massoniana in the Three Gorges Reservior Area in China**

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Abstract: Decomposition experiment was conducted to research the fine root decomposition dynamics and nutrient release, whose diameters is less 0.5mm, 0.5-1mm and1-2mm respectively, in Pinus massoniana at Jiulingtou Forestry Center in Three Gorges Reservior Area in China. The results showed that: (1) the fine root decomposition rate of Pinus massoniana was decreasing with the root diameter increasing, and the fine root remaining percentage was 66.0%, 72.0% and 74.33% respectively, whose diameters was less 0.5mm, 0.5-1mm and 1-2mmrspectively. (2) the transfer model for C, K and Mg of fine root was releasing, while it was enriching for Ca. (3) the transfer model for N and P of fine root was different, the transfer model for N and P of the fine root, whose diameters was less 0.5mm, 0.5-1mm, was releasing, and that of 1-2mm fine root was enriching. In this paper ,we analyzed the decomposition rate and nutrient release dynamic for C, N, P, K, Ca and Mg of Pinus massoniana fine root with different diameters, the result was helpful to realize the root natural decomposition processes of Pinus massoniana and also to supply the theoretical basis for the research of root nutrient cycle in the area.

Pinus massoniana,fine root ,Three Gorges Reservoir

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1175 **Fine root biomass and longevity of trees and understory vegetation in northern Finland**

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Abstract: Globally, fine root production is estimated to contribute about one third of annual net primary production. The boreal forest is a fragile ecosystem; the belowground C pool can be labile even though the temperature changes only slightly. Finland is one of the most forested countries and its forests belong to the boreal forest zone. The main Finnish broad-leaved species is birch, however, no one in Finland has so far compared how broad-leaved forest differ from coniferous forest in terms of fine root biomass, longevity and production. We aimed to evaluate all these factors at Kivalo, northern Finland. We used minirhizotron (MR) method for estimating fine root longevity and soil cores for fine root biomass. Our results showed that birch fine root median longevity (371 days) was shorter than that of spruce (714 days; published by Leppälammi-Kujansuu et al. (2014)), while understory belowground parts lived longer than tree fine roots. Fine root biomass of birch and spruce was 465 and 336 g m-2, respectively. Birch fine root biomass was over 3.5 times higher than that of understory. Our results contribute to predicting fine root biomass and turnover rate in boreal forests, particularly in the Nordic countries.

minirhizotron, fine root, turnover, boreal forest.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3990 **Carbon allocation patterns in Estonian coniferous forests**

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Abstract: Soil carbon enacts a vital role in climate regulation, water supplies and biodiversity, therefore providing essential ecosystem services. The volume and dynamics of soil carbon, of which the majority is derived from fine roots, determine the quantity and quality of these services.

The aim of the current study was to determine the variability of carbon (C) allocation in different coniferous forests along the gradients of soil moisture and fertility. We measured C stocks and fluxes, such as litter, fine root biomass and production, soil respiration etc. in 4 Scots pine (*Cladonia*, *Vaccinium*, *Myrtillus*, *Fragaria*) and 4 Norway spruce stands (*Polytrichum*, *Myrtillus*, *Oxalis*, *Calamagrostis* alvar). The ratio of above- and belowground litter production (AG/BG) was used as a characteristic of carbon allocation in forest ecosystems.

The estimated AG/BG ratio, varying from 0.5 to 3.0, tends to decrease with increasing soil organic horizon C/N ratio. This indicates that in less fertile sites more carbon is allocated into belowground through fine root growth and in consequence the soil organic carbon stock increases. Stands net ecosystem exchange varied from -1.64 to 3.95 t C ha^{-1} yr^{-1}, whereas older stands tended to be net carbon sources.

Forest ecosystem carbon allocation depends on many factors, of which site fertility plays a major role.

soil carbon, forest NEE, carbon balance, fineroots

Poster Exhibition Thursday

123 - Roots and Ecosystem Services

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1842 **Adjustment of absorptive roots and mycorrhizal fungi to nitrogen and phosphorus additions in a Chinese fir plantation**

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Abstract: Trees have developed various strategies to adapt to soil nutrient conditions through adjusting production, morphology and architecture of the absorptive roots, and their associated mycorrhizal fungi. However, the relative importance of these strategies in their response to nutrient additions remains unclear. To fill this gap, we measured biomass, length density, morphology, architecture and mycorrhizal colonization of absorptive roots after four years of nitrogen (N) and phosphorus (P) additions in a 16-year-old Chinese fir (Cunninghamia lanceolata) plantation in Southern China. Our results showed that P addition significantly reduced absorptive root biomass, length density and mycorrhizal colonization by 37%, 31% and 30%, respectively. Specific root length was increased with P addition, which might compensate for the decline in absorptive root production. Moreover, P addition led to an architectural adjustment at the root system level with a higher proportion of absorptive roots in the deeper soil. In contrast to P addition, N addition did not have significant effects on these indices. These results suggest that abundance and traits of absorptive roots and mycorrhizal symbionts together shape the integrated adjustments of root and mycorrhizal systems for nutrient acquisition.

absorptive root, mycorrhizae, nutrient acquisition

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2758 **A dynamic 3D coarse root architecture model to study anchorage of forest trees**

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Abstract: Storms cause half of primary damages to European forests, mainly by anchorage failure. Anchorage is largely determined by 3D coarse root architecture. To characterize anchorage as a function of tree age, a description of 3D root development and growth is needed.
A large database of static 3D measurements of root systems structured in a chronosequence was available for Pinus pinaster. P. pinaster do not grow adventitious roots nor show retarded development, therefore anchorage has to be carried all the life of the tree by the early grown coarse roots.
The "Root Typ" architecture model was calibrated to simulate the development of distinct root types using a limited number of parameters by root type. The analysis of root systems chronosequence displayed specificities of P. pinaster. Roots do not taper at branching point but they taper between branching points especially near the stump showing thigmomorphogenetic responses. Branching angle do not vary as a function of distance from the collar. The inter-lateral distance decreases at the water table contact and vertical roots deflect to a horizontal growth direction when they reach the hard pan.
The simulated root systems can be used in biomechanical models to test anchorage variability.

Anchorage, growth model, Pinus pinaster

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1329 **Abies and its mycorrhiza on global scale**

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Abstract: Ectomycorrhizal symbiosis is a significant component of forest ecosystems in the boreal, temperate, and Mediterranean climate zones. It has been shown, that Abies species host several naturally occurring ectomycorrhizas. The current knowledge of fir symbionts is predominantly based on morphological and anatomical descriptions of ectomycorrhizas. Beside morphological-anatomical descriptions of ECM, many studies have focused on survey of fungal fruiting bodies.
Samples were (and are still) collected from three different plots in Slovenia on adult's trees of Abies alba, once per month. From collected samples ectomycorrhizal fungal symbionts were described based on morphological and anatomical descriptions and characterized as mycorrhizal morphotypes. Further each ectomycorrhizal morphotype were identified on genus level with molecular analysis. As the research is still in progress, ectomycorrhizal fungal types are going to be identified by the species exact with phenological methods.
Until now 27,000 ECM root tips of Abies alba have been analyzed. With morphological and anatomical descriptions over 25 different ECM morphotypes of silver fir have been determined. Based on molecular analysis, most abundant silver fir symbionts are (identified on genus level): Sebacina sp., Cenococcum sp., Tomentella sp., Russula sp., Amphinema sp., Amanita sp., Inocybe sp., Boletus sp., Lactarius sp., Clavulina sp. etc. As inside the same ECM fungal genus, apparently different species occur, further phenological analysis will be used to determine morphotypes by ECM fungal species exact.
We have recorded high ectomycorrhizal diversity on Abies alba, and high spatial diversity. An unexpected high temporal diversity in some part of the year, indicates a need for more frequent sampling and diversity analysis. As for other species of Abies the data on ectomycorrhizal is spare, additional sampling would help to fill the gaps in geographical distribution of Abies spp ectomycorrhizal symbionts.

ectomycorrhiza, Abies alba, species diversity

Poster Exhibition Thursday

66 - Water Related Ecosystems Services under Risk

KG II - HS 2121 (Uni Freiburg)

IUFRO17-758 **Assessing stream flow sensitivity to drought on forested catchments in Brazil**

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Abstract: Stream flow drought response mainly depends on physical characteristics related to groundwater recharge. Many factors like slope, soil texture and depth and geology are known as the most important controllers of stream flow response. On forested catchments with high evapotranspiration rates, is it possible that forest management could modify natural response increasing or decreasing catchment sensitiveness. We present stream flow response to drought in forest catchments covered by native forest, pinus and eucalyptus plantations at southeast region of Brazil, the most affected region from recent drought events. Discharge measurements were conducted using weirs and water level loggers along 5 years of monitoring, as part of a Cooperative Program for catchment monitoring in Forest Companies (PROMAB). Annual stream flow data were compared among catchments and between normal and low precipitation hydrological years. Paired catchments data were also used in order to understand forest management effects. Results have confirmed that physical variables determine main patterns of stream flow response, showing different patterns of sensitiveness to drought. Based on results, a framework for catchment sensitiveness classification is proposed in order to predict their response. Experimental results from catchments with similar physical conditions (paired) show that forest management could modify stream flow response, especially on highly sensitive catchments. Many forest management alternatives are discussed in order to avoid drought impacts and increase resilience of catchments covered by forest plantations.

flow regime; forest hydrology, evapotranspiration

Poster Exhibition Tuesday

15 - Impacts of environmental changes on growth and productivity of managed and unmanaged forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2659 **The effects of soil characteristics on the growth of Fraxinus rhynchophylla, Zelkova serrata, and Pinus koraiensis seedlings planted under different canopies**

Park, B. . B.* (1); Ko, Y. (1); Song, J.-H. (1); Meng, L. (1); Han, S. H. (1)

(1) Chungnam National University, Daejeon, Korea, Republic of (South Korea)

Abstract: Canopy and soil characteristics are critical for the initial growth of planted seedlings with their performance properties. We translocated two distinctly different soils between Pinus rigida and Quercus acutissima stands and planted 1 year old Fraxinus rhynchophylla, Zelkova serrata, and Pinus koraiensis seedlings under the stands. Briefly, sandy Loam (SL) has lower pH and higher organic matter than Loamy Sand (LS) and light availability is higher in P. rigida stands than Q. acutissima. Height and root collar diameter growth of three species was observed for 3 years. Influence of canopy and soil properties on seedling height and diameter differed among species. Mean height of F. rhynchophylla and Z. serrata at P. rigida stands was higher in the SL than LS, but that of P. Koraiensis at P. rigida stands was independent of the soil properties. Contrary to P. rigida stands, height of F. rhynchophylla and Z. serrata at Q. acutissima stands was not significantly influenced by soil properties, but that of P. koraiensis was higher at SL than LS. Root collar diameter showed similar patterns of height growth among treatments. The results confirmed that the growth of planted seedlings was significantly influenced by soil type and canopy characteristics. We found that soil characteristics were more strongly correlated with F. rhynchophylla and Z. serrata seedling growth at high light available stands, but at low light conditions, P. koraiensis growth was influenced by soil characteristics.

light availability regeneration soil translocation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1457 **Toward modelling the influence of wind on the Maritime pine growth**

Rajaonalison, F.* (1); Bosc, A. (1); Bonnefond, J.-M. (1); Debesa, S. (1); Gardiner, B. (1); Garrigou, D. (1); Kubath, R. (1); Defossez, P. (1)

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Abstract: Understanding how trees respond to changes in climate and management practices is crucial for wood-based industries and forest sustainability. This particularly concerns the Landes forest (Aquitaine, France), the largest forest in Western Europe (10M hectares of Maritime pines). To date focus was done on the influence of temperature and water availability on tree growth. But wind-induced swaying can also influence tree growth and development. An experiment was established in a 12-year-old Maritime pine stand in which 6 trees were guyed to tree swaying, 6 trees guyed and thinned, 6 trees thinned and 6 controls. Radial growth was monitored at 3 trunk heights at monthly intervals for 2 years. Radial growth significantly reduced in the guyed trees. The positive thinning effect on growth appears to be largely due to increase in wind solicitation. This study demonstrated that chronic wind impacts the maritime pine growth allometry. This should be accounted in addition to other climatic stresses. With the development of processed based models of tree growth it is now possible to incorporate the different climatic factors directly and to accurately account for their influence. This study is a first step for considering the influence of wind on a maritime pine growth model.

wind,growth,model,thigmomorphogenesis,MaritimePine

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1133 **Carbon sequestration potential and biomass accumulation by Sal forests of Doon valley (India)**

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Abstract: The present study determines and juxtaposes biomass and carbon density of Sal (Shorea robusta) dominated forests (protected and unprotected) of Doon valley, a part of western Himalaya, in Uttarakhand (India). Volume equations were found suitable for biomass and carbon calculation and hence used in the present study. The total tree biomass and carbon density recorded from the ANR (183.11 ± 0.72 and 209.44 ± 0.34 tonnes/ha respectively) was higher as compared to the unprotected area (157.68 ± 6.92 and 180.34 ± 0.69 tonnes/ha respectively), Sal being the major contributor in both. Biomass and carbon density have a positive correlation and were found significantly different. However, co-dominant species like Milletia pinnata, Syzygium cumini, Mallotus philippensis, Terminalia tomemtosa, Bridelia retusa also contributed a substantial amount to determine the forest carbon. Soil organic carbon (SOC) at the protected site was 0.97%, whereas unprotected site recorded 0.83% OC. Available Nitrogen, available phosphorus and percent available potassium are found to be same at both the sites, whereas moisture and pH at the protected site is higher when compared to the unprotected site. Analysis showed that ANR will help in achieving higher carbon sequestration potential while offering significant cost advantage as it supports natural regeneration and reduces or eliminates the costs associated with propagating, raising and planting seedlings, involves community participation supplying substantial benefits to local people and will help the policy makers and researchers understand the significance of techniques used in ANR and their role in regional and global CO2 cycle.

carbon density, organic carbon and volume equation

Poster Exhibition Tuesday

15 - Impacts of environmental changes on growth and productivity of managed and unmanaged forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-344 **A multi-decadal analysis of patterns and processes in Venezuelan tropical forests: insights from permanent sample plots**

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(1) University of Washington, SEFS, Universidad de Los Andes, INDEFOR, Seattle, United States; (2) Universidad de Los Andes, Venezuela, Mérida, Venezuela, Bolivarian Republic of; (3) Univ. Nacional Exp. de los Llanos Occidentales , Barinas, Venezuela, Bolivarian Republic of; (4) Univ. Nacional. Exp. de Guayana, Ciudad Bolívar, Venezuela, Bolivarian Republic of; (5) University of Washington, Seattle, United States

Abstract: Long-term data collected from a wide range of forest conditions provides an excellent opportunity to examine the underlying processes that drive variations in species diversity, aboveground carbon stocks, and forest dynamics. Here, we use data from 53 permanent plots ranging from 0.25 - 1 ha in area, and with 8 to 55 years of information in contrasting ecological conditions of tropical forests of Venezuela, South America to: 1) investigate the main processes of tree dynamics (mortality and recruitment); and 2) analyze the patterns of aboveground wood productivity (AGWP) across several forest types. We test the hypothesis that the pattern of tree turnover is a good predictor of wood productivity among all sites. A consistent positive trend in both mortality (+ 1.26 % year^{-1}) and recruitment (+ 1.04 % year^{-1}) rates was found across all sites. Tree mortality rates are significantly different between less productive and dynamic forests (i.e., stands with < 2 % year $^{-1}$ turnover rate) in the Guiana Shield, and Cloud forests in the Andes, than those from more productive and dynamic forests located in western plains alluvial terraces. Forests limited by soil fertility (e.g., Guiana Shield) or by temperature and altitude (e.g., Andean cloud forests) on average have 37% more aboveground biomass than western plains forests. Furthermore, on average, AGWP was 2.17 Mg ha $^{-1}$ year^{-1} across highly dynamic areas, 29% higher than the rate estimated for forests with lower turnover. Since tree biomass is strongly controlled by wood density, a higher biomass, and thus carbon, is being stored in slow-growth forests of the Guiana Shield and high elevation forests in the Andes, with lower values in the fertile alluvial zones of the Western Plains region. We found no clear relationship between wood productivity and tree diversity with mixed results across all plots.These results are useful for improving models used to understand the effects of climate change in tropical forests.

biomass; turnover; mortality; tropical forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-645 **Stature change as reflected in height-diameter growth of Erman's birch at the treeline and along an altitudinal gradient on Changbai Mountain, Northeast China**

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Abstract: Tree stature depends on allometric growth of height and diameter. It will change with climatic conditions because height and diameter growth display different sensitivities to climatic factors such as temperature. Detecting changes in the stature of trees at the treeline can help us better understand the strategy of trees in adapting to severe cold conditions. In this study, height-diameter datasets for 2,723 Erman's birch (Betula ermanii Cham.) at the treeline on Changbai Mountain in northeast China in 2006 and 2013; and for 888 Erman's birch, spruce (Picea jezoensis (Siebold & Zucc.) Carr.), larch (Larix olgensis A.Henry), and fir (Abies Nephrolepis (Trautv. ex Maxim.) Maxim.) in 2006 along an altitudinal gradient below the treeline; were utilized to explore both changes in stature of birch at the treeline over time, and static relationships in tree stature across altitudes at a given point in time (2006). Both are reflected in height-diameter relationships. Results showed that stature change of different tree forms (upright, shrubby and sapling) at the treeline varied over the study period; saplings became stunted while the others became more tapered. The stature of birch along the altitudinal gradient became more tapered from 1,700 to 1,900 m asl; and then became more stunted from 1,900 to 2,050 m asl, with 1900 m being the altitudinal inflection point in this pattern. Compared to the other species, birch displayed high stature-plasticity in terms of its height-diameter ratio more fluctuate. On an overall basis, the stature of birch is modulated by altitude-related temperature to a significant degree; while at the severely cold treeline, it is related to tree size, tree form and micro-habitat. High stature-plasticity characteristic of birch makes it fare better than other species in terms of survival at the treeline.

Allometric growth; Tree forms; Erman's birch

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2187 **Is the pattern of pedunculate oak mortality related to commonly used forestry practices?**

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Abstract: *Quercus robur* is one of the most valuable forest-forming tree species native to Europe. To survive periods of water deficit occurring during long lifespan of oaks, they developed a deep taproot system. Unfortunately, the production of oak seedlings in nurseries disturbs the natural development of oak root systems by repeated taproot pruning. Such practices likely lower the potential of oaks to survive long-term drought, since lateral roots are not able to substitute the truncated taproot. To check whether the pattern of oak mortality is related to forestry practices, we used dendroclimatological and stable isotope techniques to investigate the physiological responses of acorn sown, planted and coppice managed oaks to drought stress. We reveal that reduction of ring-width during the drought periods was found for all cultivation types, however the scale of such depression and tree vitality strongly depended on planting methods. In additions, signature of δ 13C and δ 18O of weakened trees varied between the oak cultivation types. Given that lower water access has the negative physiological consequences, the lack of a taproot could have a marked impact on forest stability by increasing their mortality during drought periods.
The research has been supported by the National Science Center, Poland (Project 2011/01/D/NZ9/02871).

oaks, taproot, forestry practices, drought

Poster Exhibition Tuesday

140 - Forest education - the consequences of interaction: innovation and curricula

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3492 **Machine simulators as pedagogical tools in forest machine operator training: A needs analysis**

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Abstract: Forest machine simulators are currently used in many Swedish forest machine training programs. However, it is clear that neither the simulators nor the usage at the schools have been developed with clear and easy pedagogics for young students. Thus, in 2016, a three year development project has been initiated by SLU and two training schools in Sweden. In this project the schools work in close cooperation with simulator manufacturers. The aim is to develop the pedagogics and widen the scope of skills that can be trained with machine simulators. An initial needs analysis has been conducted, based on which a checklist for educational forest machine simulators are developed. The checklist focuses on two different roles and their needs; the teacher's needs and the students' needs. While students should be able to keep track of their progress (where am I going, how do I do, and what is my next step?) there is a need for the teacher to be able to evaluate and grade the progress of their students. While improving the simulators and their usage, the education of new forest machine operators will also improve and the attractiveness of the forestry training programs may increase.

Education, Forest machine simulator, School

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3532 **Progress tests in Forest Education**

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Abstract: Students and teachers need information about the learning outcomes for guidance and monitoring purposes. Valid and accurate measurement of learning outcomes could provide useful material for personal student-teacher guidance discussions. Especially quantitative measurement of learning outcomes is needed when education institution is monitoring the outputs of education.
Progress test is standardized measurement of learning outcomes. It is typically concerning the core knowledge of education and it is based on repeated measures during the education period such as 3-4 years for BSc students. For instance, all students from the first year up to the graduation are aimed to take the test at least annually. The first progress tests in tertiary education have been established in medical education already 1970s.
Technically tests are typically implemented using true-false or multiple choice measures. One of the challenges with progress tests is that they cannot easily measure generic skills.
To our knowledge there has been to date no progress tests in forest education. University of Helsinki has established 2015 the progress test for the BSc programme of forest economics and marketing. To our knowledge the test is the first one in the field of forest sciences. The data is now gathered and some first results are available in summer 2017.

progress test, learning outcomes, monitoring

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1985 **Possibilities of using retention reservoirs in forest the ecological education conducted by polish State Forest**

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Abstract: In recent years, Polish forests, mainly those managed by the State Forests of National Forest Holding more than a thousand reservoirs were created and their aim is to increase the capacity of retention of the forest. The issue of water management in forests is included in the education of nature and the forest. The article shows the possibility of the use of facilities for retention conducted environmental education. For this purpose, an on-line survey, involving 450 respondents and analyzes offer production and trade of the leading Polish companies dealing with equipment in forest in appropriate recreational infrastructure and education. The results show that, according to most respondents (96.5%) reservoirs can be an attractive element of education, natural-forest. About 20% of respondents were interested in obtaining information about the features of reservoirs. A total of 36.7% of the respondents would like to expand their knowledge of aquatic plants or animals of the forest reservoirs. At the same time 12.1% of respondents thought that water tanks should be used in education to discuss the retention function of the forest. Analysis of the market offer in terms of equipment in forest in educational infrastructure shows that this offer is limited almost exclusively to the information boards. Most of the tables presents issues concerning the characteristics of wetlands (bogs, swamps, alluvial forests, etc.), the inhabitants of aquatic ecosystems, water cycle, its importance in nature and the causes and effects of the degradation of waters. Few in Poland are examples of educational infrastructure aimed at portraying role of forests in mitigating the effects caused by a deficiency or excess of water, operation of hydraulic structures, as well as the cultural significance of water in the woods.

forest education, water, social preferences

Poster Exhibition Tuesday

Pine wilt disease: progress in understanding the dynamics and developing control measures

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1779 **Induced resistance in Pinus pinaster against pinewood nematode (Bursaphelenchus xylophilus)**

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Abstract: Pinewood nematode, Bursaphelenchus xylophilus, is considered a quarantine pest in the European Union, since it causes the pine wilt disease, which is a serious threat to European coniferous forests. Pinus spp. are the most susceptible hosts and specifically Pinus pinaster has been reported as highly susceptible in several studies. However, resistance mechanisms against pinewood nematode are still unclear. We developed two inoculation assays on a Pinus pinaster family, where different pretreatments where compared. Pretreatments consisted on spraying six different treatment solutions on plant needles twice a week during 4-8 weeks before inoculation. Among the pretreatments used in the first assay, the protocatechuic acid pretreatment obtained lower mortality than the water pretreatment (control), even though it was not significant. In the second assay, protocatechuic pretreatment was compared to the control, but applying it for a longer period of time and in two higher doses. Significant differences were obtained this time, achieving higher survival in the plants pretreated with both protocatechuic acid doses than in the control plants. We discuss causes of this tolerance increase.

Protocatechuic acid, pine wood disease

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3179 **National survey (2010-2016) of the pinewood nematode vectored by the insect Monochamus galloprovincialis in Portugal**

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Abstract: Pine wilt disease (PWD) is one of the most important threats to conifer forests worldwide and results from a complex interaction between three very distinctive biological agents: the pinewood nematode (PWN), Bursaphelenchus xylophilus, its insect-vector, Monochamus galloprovincialis, and the host tree, Pinus spp. PWN is vectored from wilt-killed to healthy pine trees by the insect-vector when the adult beetle feeds on young branches, annually killing thousands of pines in Portugal since its introduction in 1999. Each year, a national monitoring program using a grid of multi-funnel traps baited with specific attractants is implemented during insect's flight period. The insects are collected periodically, nematode extraction performed and infection rate in each beetle is assessed. The results of six years of national trapping (2012-2016), comprising thousands of insects' analyses, are presented to describe the evolution and spatial spread of this disease, until the present situation in Portugal. Additionally, constrains of the monitoring system are discussed.

Bursaphelenchus xylophilus, pine wilt disease

Poster Exhibition Tuesday

186 - Changing forest disturbance regimes: Patterns, consequences, and responses

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2924 **Current Post Fire Reforestation Strategies in Turkey: An Overview**

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Abstract: Forests are vital for sustainable development and human wellbeing globally. Although forest fires are an integral part of most Mediterranean forest ecosystems, fires can also be a major threat to forest sustainability. In Turkey, about twelve million hectares of forested lands are under the threat of forest fires with about twenty thousand hectares burned annually. Burned areas have to be revegetated naturally or artificially within a year as mandated by the Turkish forest law. Since 2008, burned areas have been redesigned to minimize fire loss and increase the resistance of forests to fire with the implementation of the project called Rehabilitation of Burned Areas and The Establishment of Fire Resistant Forests (YARDOP). In this project, the structure of the landscape is redesigned using buffer zones at wildland-urban and forest-agricultural interface with widths up to 100 m planted with different local less flammable plant and non-wood plant species with economic value. The total cost of the 101 projects implemented to date have been approximately ninety million USD, and the total area reached is about 200.000 hectares as of the end of 2016. The objective of this study is to present and evaluate the current post fire reforestation strategies and the large scale fuel management projects such as YARDOP from ecological, economic and social aspects. Results obtained from the study indicate that experiences gained from YARDOP projects are important and require genuine attention as many countries are struggling with fire problem in similar environmental conditions in the Mediterranean countries in particular and in the world in general.

Forest Fires, Post Fire Management, Reforestation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3799 **Forest Fire regime in Latvia: 1922-2014**

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Abstract: As fire activity is strongly determined by climatic variables, the ongoing climate change can alter current temporal and spatial patterns of fire activity in hemiboreal forest zone. It is therefore of interest to understand trends and changes in regional fire activity during last century in Latvia when national fire statistics is available. Evaluation of relationship between fire activity and different fire weather indices could potentially benefit fire prevention measures in future.
Historical forest fire data were obtained from literature (1922-1940), archives (1975-1984) and State Forest service (2004-2014) database. Weather data (1975-2014) were obtained from "Latvian Environment, Geology and Meteorology Centre". Weather conditions were characterised by Nesterov index (NI), Modified Nesterov index (MNI) and Canadian Fire Weather Index (FWI).
Non-parametric Mann-Kendal test for trend analysis and Chi square test for comparison of distributions were used in data analysis. Spatial analysis was carried out in ArcMap 10.1.
In the period 1922-2014 mean occurrence of forest fires were 628 ±38.4 per year, the mean burned area 1049 ±194.5 ha per year. A significant trend of gradual decrease of fire occurrence and mean burned area per year was detected. Towards the end of 20th century the peak of fire season has shifted towards earlier spring time. Fire rotation in period (1922-2014) was 2.1 ×103 years. Spatial analysis revealed geographically clustered distribution pattern of forest fires in Latvia. Most of the forest fires occurred in close proximity of the two largest cities of Latvia - Riga and Daugavpils. During analysed periods (1975-1984) and (2007-2014) depending on index FWI, NI, MNI 4.3-4.6%, 0.7-2.3% and 0.1-0.6% days of fire season were with high or extremely high danger index. During these days 23-34%; 2.5-15.5% and 0.3-3.7% of registered fires emerged.

Fire disturbance, Hemiboreal zone, Fire weather

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3454 **Changes in forest structure and forest disturbance patterns in Korea**

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Abstract: The natural environment in Korea is characterized by four distinct seasons and mountainous topography. Most of Korean forests belong to temperate zone and experience seasonal changes in temperature and precipitation. Korean forests experience freezing winter, dry spring, hot and wet summer, and dry autumn. Those seasonal changes control the reproduction and growth of forest communities. Disturbance is a major part of forest ecosystems. Major disturbances in Korean forests include wildland fire, landslide, and pest insect and diseases, and are closely related to seasonal weather. Each season has characteristic disturbances in Korea. Dry spring induces drought stress and wildland fire. High precipitation and typhoon in the summer cause landslides and soil erosion. Pest insect and diseases are prevalent in spring and summer. Thus disturbance occurrence in Korea is different annually and affected by annual weather pattern. Climate change is suspected to affect seasonal weather and bring unexpected weather events, which can affect forest disturbances. Korean forests have experienced drastic changes in forest structure from poor and extremely degraded forests in 1950s and 1960s, through nation-wide reforestation in 1970s and 1980s and to fully stocked forests, altering major pest insect and diseases in Korean forests. This study looked into temporal changes in forest structure and disturbance patterns in 1970s-2010s in Korean forests.

wildland fire, landslide, tempoeral changes

Poster Exhibition Tuesday

186 - Changing forest disturbance regimes: Patterns, consequences, and responses

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2640 **Temporal patterns of OM and nutrient fluxes with soil solution as affected by low-severity fire in beech forests and pastures**

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Abstract: The changing climate will promote extreme weather events that in turn increase drought periods and the abundance of fire in Europe. The impact of fires on temporal patterns of element fluxes is highly diverse and fire can strongly alter the distribution, binding forms and availability of organic matter and associated nutrients in soil. The present study aims to elucidate the effects of low-severity fire on the mobilization of dissolved (DOM) and particulate organic matter (POM) and nutrients in soil solution (0-4 cm) during one-year biweekly monitoring in beech forests and pastures in the Hainich region, Central Germany.
Linear-mixed-model procedure revealed significant increases of dissolved nitrogen (TDN) fluxes and land-use specific fire effects for water flux, POM and S fluxes. In the forest, fire induced a short-term and a time-delayed increase of S (105%) and TDN (218%), respectively, associated with accelerated mineralization rates in spring and reduced nutrient-uptake rates due to missing ground vegetation. The study demonstrated how low-severity fires can increase the risks of nutrient losses from the forest ecosystem and how the dynamics of different nutrients can be decoupled with time. It is likely that even low-severity fire can affect nutrient cycling with consequences for primary production in the longer-term.

dissolved and particulate OM, element fluxes

Poster Exhibition Tuesday

82 - Traditional coppice: ecology, silviculture and socio-economic aspects

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1920 **Silvicultural coppice management of Quillaja saponaria (quillay or soapbark tree) native forest for industrial uses in central Chile**

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Abstract: The traditional use of *Quillaja saponaria* (Quillay or Soapbark tree) was restricted to extract only the bark of large trees, because exhibits a high concentration of saponin, used for many industrial purposes. This has caused ecological and economic damage to the native sclerophyll forest of Chile. A sustainable coppice or coppice with standard silvicultural management regime for industrial production of saponin is proposed. It consists of an improvement cutting with clearing, thinning and pruning of sprouts. It also includes the cutting of part of the large individuals, senile and/or with health problems, to induce sprouting. Also, the silvicultural regime considers retaining a proportion of old individuals of quillay for: regeneration, maintenance of landscape and biodiversity, shelter for wildlife and livestock, considering also forest enrichment by using quillay plants and/or other sclerophyllous species in order to increase the coverage and forest biomass. The silvicultural management proposed, unlike the traditional use of quillay bark only, would allow using woody stems and branches of small dimensions, increasing the commercial biomass growth and decreasing the period between harvests. The proposed regime would allow combining industrial with other traditional uses and/or non-timber forest products, contributing towards the conservation of native forest of central Chile.

coppice, biomass, saponin, sclerophyll, Chile

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2455 **Restoration of plant diversity in oak coppices converted to high forests under global environmental threats**

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Abstract: Conversions of oak coppices to high forests, widely applied in temperate Europe during the last century, caused vast decline of plant diversity and species assemblage shifts to mesic communities. Therefore, the biodiversity restoration of abandoned coppices is important task for forest and nature conservation practice. However, a simple restoration of traditional management may not ensure the recovery due to the global environmental changes. Based on current knowledge synthesis, this study identifies and offers insights on the major environmental threats to plant diversity restoration in oak coppices.
The crucial driver of vegetation changes is the eutrophication induced by nitrogen deposition and accumulation of organic matter. The impact of increased nitrogen on understorey vegetation could be inhibited by decreased light availability due to the increased canopy closure. Therefore, opening of forest canopy as a restoration tool may trigger rapid nitrogen release and consequent undesirable mesophication and diversity loss. Moreover, increased light could accelerate impact of global warming and result into thermphilization of plant communities. Next relevant threat are the plant invasions, which are enhanced by both higher nutrient availability and climate changes. Further research should develop appropriate techniques for biodiversity restoration that mitigate these environmental threats.

biodiversity, global changes, forestry

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3307 **Transformation of Castanea sativa coppice forests by selective stump reduction: chemical, physical and mechanical methods**

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Abstract: Castanea sativa Mill. in North-East Spain has been managed traditionally as low coppice, mainly for poles production. However, since the middle of the XX century the species has been intensely affected by the chestnut blight, which reduces the quality and value of the timber. At present, there is an increasing interest in the transformation of chestnut coppices into low-density forests with main objective of fruit production, which is perceived by forest owners as an alternative in low site quality areas. However, this transformation is not an easy task, since it requires an intense selective removal of most of the existing stumps, being expensive and not always a successful treatment.
In this study, we tested 6 methods for the selective reduction of chestnut stumps: (i) 3 chemical treatments, (ii) 2 physical treatments and (iii) 2 mechanic treatments. We evaluated the effectiveness of the treatments (re-sprouting intensity in the following spring) and phytotoxicity side-effects in untreated chestnut stumps contiguous to those treated with herbicides. In general, chemical and mechanical treatments provided the best results and physical methods showed no significant differences with control plots. Herbicidal treatments presented null to very low levels of phytotoxicity.

Chestnut, fruit, herbicides, stump removal

Poster Exhibition Tuesday

82 - Traditional coppice: ecology, silviculture and socio-economic aspects

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3646 **Silvicultural methods for beech and mixed oak coppice stands managed by the Serbian Forest State Enterprise**

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(1) Institute of Silviculture,Vienna, Wien, Austria; (2) Directorate for Forests, Novi Beograd, Serbia; (3) Public Enterprise Srbijasume, Belgrade, Serbia; (4) Faculty of Forestry, Belgrade, Belgrade, Serbia

Abstract: The Serbian forest state enterprise manages about 300.000 ha of coppice forests, dominated by beech and mixed oak stands. Due to the high share of even-aged 50 - 80 years old stands silvicultural opportunities are sought for future management. Regarding the conversion towards high forest stands the objectives were to favour high quality sprout-originated trees by early singulation of shoots and a continuous raise of volume (value) by thinning from below (thinning intensity 5-15 %).This method resulted in false high forest stands with a high stem number density combined with small crowned trees and low diameters. Based on preliminary investigations we assume in contrast to the defined rotation period of 80 years, that on moderate sites within a period of 20 - 40 years a target diameter of 40 cm of good quality trees could be achieved. Therefore one has opted for the treatment paths i) thinning [heavy selective thinning from above, thinning, regeneration] and ii) regeneration [preparation/seed cut, shelter cut, removal cut]. First treatment steps were implemented in demonstration plots during a tree marking course for staff members. Based on a silvicultural event analysis including economic aspects, consequences for decision making on stand and enterprise level are discussed.

coppice forest, silviculture, forest management

Poster Exhibition Tuesday

45 - Forest policy and biodiversity strategy: The relevance of forest genetic resources

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1802 **Forest genetic monitoring: laws and obstacles for its implementation in Greece**

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Abstract: The cornerstone of forest biodiversity survival is the in situ conservation of genetic resources and forest genetic monitoring (FGM), the quantification of temporal changes in population genetic variation and structure, can serve as an early warning mechanism for changes that on higher levels could only be seen later on. A proof of principle for FGM is currently implemented in the LIFEGENMON project. However, for FGM to succeed, it must become easily integrated in State environmental policy. In Greece, such integration should be straightforward: the country is a biodiversity hotspot, environmental protection is embedded in the Constitution: "the protection of the natural and cultural environment constitutes an obligation of the State" (Article 24). Following the Rio declaration Greece was committed in establishing 359 Natura2000 sites. However, Greek environmental policy is complex and governed by 27 principal legal documents that include Laws, Decree Laws, Presidential Decrees, Joint Ministerial Decisions and Ministerial Decisions. Jurisdiction is fragmented between different authorities (e.g. Ministry of Agricultural Development and Food, Ministry of Environment and Energy). Only recently gene diversity has been included under biodiversity protection (Law 3937/2011). The impact of environmental laws complexity, the fragmentation of jurisdiction and intricate bureaucratic procedures, on potential FMG implementation is discussed.

Forest Genetic Monitoring, Forest Laws, Greece

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4074 **Ring testing in forest genetic monitoring**

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Abstract: Although fragment analysis of microsatellite loci remains the mainstay technique in forest population genetics, genotyping and genetic monitoring (FGM), due to high per-marker discriminating power and established analytical procedures, results of fragment analysis are not universally comparable. If studies using microsatellite markers were to be replicated, directly compared or run in parallel between different laboratories, adjustment of raw data must be performed. For that purpose, institutions participating in LIFEGENMON performed an inter-laboratory comparison, i.e. ring testing. Objectives of the ring test included devising a set of rules allowing direct inter-laboratory comparison of results and assessment of technical suitability of selected markers for FGM. Each laboratory analysed the same 30 samples for each of the two tested tree species - beech (Fagus sylvatica) and silver fir (Abies alba) - performing DNA extraction, PCR and fragment analysis. Pairwise sizing difference tables were prepared for direct translation of results between laboratories for 22 of the 24 tested markers. Two markers were discarded due to technical issues. Observed differences in allele sizing between laboratories could not be explained purely as a systemic error due to different detection platforms but apparently depend on a complex set of factors including effects of flurophores, fragment size and marker-specific effects.

Ring test, microsatellite markers, LIFEGENMON

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1838 **National legislation of forest reproductive material: case of a wide spread Silver fir (Abies alba) and Serbian spruce (Picea omorika)**

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Abstract: Production and use of forest reproductive material (FRM), and its monitoring are presented on th ecase of two coniferous species inBosnia andHerzegovina.
Silver fir respresents the most important coniferous species in the country, and is a perfect subject for verification of monitoring of genetics diversity, production and use of its RM. Silver fir shows specific variability from the south-east to north-west. Currently there are several suggestions for the approvaland use of Silver fir genetic resources, however its monitoring is yet to be developed. Our main problem to address is to follow transfer of the genetic structure from the adult to the juvenile generations through natural or artificial regeneration.The success of conservation of genetical variability of a juvenile population can only be successfully done by monitoring using molecular markers, which yet has to be incorporated into national legislation.
Serbian spruce grows in 16 main small disjunct population s through out the river Drina in Bosnia and Herzegovina. We studied genetic structure of five populations of Serbian spruce from the area of Visegrad, and each of thesere presents a specific dislocated population. There is no ex change of genetic material among different populations, while also inbreeding leads to reduced genetic variability.
In practice we have to treat each of the populations separately, attention should be given to separated RM collection and manipulation, so that unintentional mixing of RM from different populations is prevented.Thus each population should be treated as a separate provenance, which so far has not been resolved in national legislation, and further monitoring of the collected RM should be proposed. Until now still all seed is declared under a single provenance of Visegrad. To conserve Serbian spruce genetic resources also establishment of a mixed source ex situ conservation orchard should be considered, and genetic monitoring established.

Bosnia and Herzegovina, legislation, monitoring

Poster Exhibition Tuesday

45 - Forest policy and biodiversity strategy: The relevance of forest genetic resources

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2255 **Design and implementation of the forest genetic monitoring database**

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(1) Slovenian Forestry Institute, Ljubljana, Slovenia

Abstract: Forest genetic monitoring (FGM) that is being implemented within LIFEGENMON project, encompasses data collection with the following characteristics: i) data are highly diverse (e. g. phenological observations or molecular data), ii) they have a strong temporal dependency with different acquisition intervals (from yearly to daily), iii) they have a strong spatial dependency and iv) data are obtained within different European institutions with varying resources for data management.

The newly devised LIFEGENMON database is trying to address these issues. It is using or taking into the account the already existing database libraries (GD2, EUFGIS), standards and protocols (ISO, INSPIRE). This allows the flexibility of merging or cross querying the LIFEGENMON database with the already existing databases if needed.

Data import is carried out by the open source data management system Open Foris Collect, while querying can be performed by a variety of options (R, inbuilt Saiku, modified version of Open Foris Calc). Open Foris Collect is based on a standard Sqlite database engine. Data import/view can be performed anywhere from within partner institutions, while the database itself is being hosted on the Slovenian Forestry Institute's servers.

The database entered its testing phase at the end of 2016.

FGM, database, Open Foris, SQLite, LIFEGENMON

KG II - HS 2121 (Uni Freiburg)

IUFRO17-200 **Development and implementation of common protocols for forest genetic monitoring**

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Abstract: High genetic diversity of forest trees ensures that forests can grow, adapt and evolve under environmental change, but they may face threats when such change occurs faster than the species' adaptive and evolutionary mechanisms can handle. It is obviously necessary to design and implement a forest genetic monitoring (FGM) system. The main tasks for successful FGM implementation are to: (i) identify regions for genetic monitoring; (ii) select genetic monitoring plots within identified regions; (iii) select indicators and verifiers for genetic monitoring. Through all three steps, it is important to have support and commitment of countries and national focal points to be able to establish FGM monitoring plots. One of the fundamental requirements needed for implementation of forest genetic monitoring is the preparation and standardization of protocols for FGM plots establishment, phenology observations and sampling. Within the LIFEGENMON project (LIFE for European Forest GENnetic MONitoring System; www.lifegenmon.si), harmonized protocols for FGM plots selection, establishment, phenology observations and sampling for genetic analysis were prepared. The monitoring protocols have been tested with the aim to evaluate and further improve after the first results of the forest genetic monitoring application will be obtained and assessed. Standardized protocols regarding the FGM plot establishment and phenology observations are presented.

FGM, standardized protocols, LIFEGENMON, phenology

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1341 **Installation of a genetic monitoring network for beech and spruce in Germany to evaluate the genetic adaptability of species to climate change**

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Abstract: Within a recent project a genetic monitoring network will be installed for beech (Fagus sylvatica) and spruce (Norway spruce) in Germany for the first time. The main goal is to assess the genetic variation and the status of the genetic system of different populations as well as its dynamics in time and space on the basis of criteria, indicators and verifiers. Therewith the effects of factors influencing the genetic system in the forests can be estimated and valuated. The genetic monitoring network will comprise 14 plots for beech and 10 plots for spruce. The methodology is based on the "Concept of a Genetic Monitoring of Forest Tree Species in the Federal Republic of Germany" but takes into account also experiences from punctual pilot studies. On each plot both genetic and phenological observation will be conducted. Genetic investigations will be based on neutral nuclear microsatellites. Based on the genotypes of the adult trees, natural regeneration and the seeds indicators for genetic processes (e.g. genetic multiplicity, diversity and allele distribution) will be calculated. New adaptive markers (SNP) related with phenotypical traits will be developed. In order to identify any critical development caused by human intervention or climate change the temporal and spatial dynamics of the genetic and demographical composition of tree populations will be simulated based on empirical monitoring data.

genetic monitoring, beech, spruce, permanent plots

Poster Exhibition Tuesday

45 - Forest policy and biodiversity strategy: The relevance of forest genetic resources

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1864 **Seeds without borders sustain forest diversity**

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Abstract: The rate of climate change, including a rise in temperature and frequent extreme events, is likely to exceed the natural adaptive potential of forests, threatening their stability and vitality. The utilization of adaptive seed material from warmer regions of tree species distribution as a silvicultural practice is expected to buffer forest stability against global temperature increase. But at present tree provenance regions, seed use and transfer regulations are regulated mainly on the national level. Forest reproductive material is marketed within countries and transnational transfer is rare. In response the Interreg Central Europe project SUSTREE brings together eight partner institutions of six countries within CE. The aim of the collaboration is the harmonization of data on tree genetic resource and adaptation to changing climate conditions. A common database enabling transnational access to forest genetic resources will support practitioners, forest nurseries and orchards to find solutions to future climatic situations. The development of seed transfer models combining new findings on climate change, tree distribution and national forest inventory data will provide tools to communicate the importance of building a policy for sustainable transnational use of forest reproductive material.

tree genetics, harmonization, adaptation, CE

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2693 **Legal framework and stakeholders' attitudes toward the conservation of forest genetic resources**

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Abstract: Conservation of forest genetic resources (FGR) is a must to ensure that present and future generations continue to benefit from forests and trees. The term FGR is present in almost all current international processes and documents related to the sustainable forests management and biodiversity protection. In European legislation, conservation of FGR is viewed through the prism of nature conservation, natural resources and the regulation of trade in forest reproductive material.
The aim of the paper is to analyze the legal framework of FGR conservation, at the international and national levels, as well as, the stakeholders' attitudes toward the legislation of FGR conservation in Serbia.
Primary data were collected by using surveys, which were conducted with 32 representatives of public administration, services and organizations in the sectors of forestry, nature conservation and environment.
It was found that in Serbia there is no legislation which directly relates to the FGR conservation. This issue is the subject of laws from the fields of forestry, production and selling of forest reproductive material, nature conservation and environment protection. The results of the analysis of the stakeholders' attitudes indicate the necessity of adopting binding legal documents, which will directly regulate the issue of conservation and directed utilization of FGR.

legislation, conservation, forest resources

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1370 **Communicating Forest Genetic Resources to Different Target Audiences**

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Abstract: Effective communication of complex biological phenomena such as forest genetic resources, forest genetic diversity and forest genetic monitoring requires innovative and adaptive approaches when addressing different, especially general, audiences. Within the LIFE LIFEGENMON project (LIFE13 ENV/SI/000148), we have the opportunity to communicate extensively and gather valuable experience about these topics. The contribution shall present general guidelines on communicating these topics and several practical examples.

General guidelines for communicating forest genetic resources include:

1. Providing context / helping your audience to see the big picture (by answering questions such as: What is genetics? What is DNA? What is biodiversity? Why are forest genetic resources important?) Make sure your audience understands the basics before deepening the discussion. When this is not possible (due to time constraints or similar), briefly explain that forest genetic diversity is essential for the survival and adaptability of forests.
2. Highlighting the importance of forest genetic resources and forest genetic diversity for the future of forests.
3. Using comparisons to familiar topics, i.e explain forest genetic diversity in a way that relates to the genetics of human or (edible) plant populations.
4. Using communication tools, suited to target audiences (brochures, comics, children's books and cartoons, toys, etc.)
5. Engaging target audiences in a continuous dialogue.

Practical examples/guidelines comprise of:
1. Communicating forest genetic diversity to children.
2. Communicating forest genetic resources to teachers.
3. Communicating forest genetic monitoring to foresters.

communication, forest, genetic, diversity

Poster Exhibition Tuesday

45 - Forest policy and biodiversity strategy: The relevance of forest genetic resources

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1657 **The role and place of forest genetic monitoring within existing forest monitoring schemes**

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(1) Slovenian Forestry Institute, Ljubljana, Slovenia; (2) Bavarian Office for Forest Seeding and Planting, Teisendorf, Germany; (3) Aristotle University of Thessaloniki, Thessaloniki, Greece; (4) Decentralized Administration of Macedonia-Thrace, Thessaloniki, Greece

Abstract: Existing forest monitoring schemes (i.e. National Forest Inventories, ICP, ManForC.BD.), provide a great wealth of valuable data on forests developing in time. A forest genetic monitoring should be shaped in a way to utilize the available resources. However existing forest monitoring schemes, either national or Europe-wide are based on stand evaluation, primarily using different sized and shaped sample plots encompassing a low number of trees. Genetic monitoring is a tool to assess the basic component of biodiversity, namely genetic diversity. In the case of forests, it entails spatial and temporal recording of the state of the forest genetic resources and the interpretation of any changes observed. Because genetic diversity and associated changes need to be evaluated at the population level, monitoring diversity on only a small number of trees might not elucidate evolutionary processes at the desired level. Therefore, a basic requirement for forest genetic monitoring should be the use of an adequate sample size (number of trees) that represents the underlying population to be monitored. The procedure to define the minimum and optimum number of trees needed for genetic monitoring based on different diversity verifiers that are used in the framework of the LIFEGENMON project and ways to include genetic monitoring into existing forest monitoring schemes, is presented.

genetic monitoring, number of trees, sample size

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4046 **Wild Plants Conservation through Seed Vault in the Republic of Korea**

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Abstract: 60 per cent of threatened plant species are in accessible ex-situ collections preferably in the country of origin, and 10 per cent of them have been included in conservation and restoration programs. In particular, seed vault (or seed banks) is valuable for preservation of genetic diversity of non-crop wild plants threatened by ecosystem and land use changes, over exploitation, invasive alien species, pollution and climate change etc. In this context, the Baekdu-daegan National Arboretum, the Republic of Korea has established seed vault, the biggest storage in Asia (4,327m^2 including medium- and long-term storage room, laboratory etc.) in the storage temperature of -20 ºC and RH 40%, and with the available capacity of more than 2 million species. The Baekdu-daegan seed vault targets wild plants and plans to conserve 1 million seeds until 2025 through collection project, entrustment of overseas botanical garden and research institutions etc. with operating relevant training and joint research programs.

seed vault, ex-situ conservation, wild plants

Poster Exhibition Wednesday

121 - Reforestation challenges: planting material, ecophysiology, biodiversity, climate change mitigation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-4058 **Partial harvesting in boreal mixedwoods: A case for planned heterogeneity in industrial silvicultural prescriptions**

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Abstract: In large areas of the boreal mixedwoods of eastern Canada, conventional forestry practices dominated by large-scale clearcutting have led to an increase in early-successional trembling aspen (Populus tremuloides Michx.) stands and a decrease in late-successional mixedwood stands. Partial harvesting could help promote a return to mixedwood composition with greater potential economic returns. The objective of this study was to identify the stand attributes that have an effect on trembling aspen regeneration following industrial harvest operations. Ninety plots were surveyed immediately before and five years after partial harvesting, to collect information on harvested trees (stumps), residual cover and pre- and post-harvesting regeneration. Using the GAMLSS package, zero-inflated beta regression models were developed to model the projected relative abundance of trembling aspen. We found that aspen abundance was positively influenced by an increase in removal percentage and by an increase in initial basal area of the species in the overstory. Abundant balsam fir advance growth had a strong negative influence on the projected trembling aspen abundance. This information could be incorporated into silvicultural prescription decision tools to suggest optimal local basal area removal targets that would limit the regeneration success of trembling aspen. Using these results, we propose a new approach that consists of deliberately introducing heterogeneity within partial cutting prescriptions in order to limit deciduous encroachment and to promote the recruitment of coniferous regeneration in eastern Canadian boreal mixedwoods

Boreal mixedwoods, partial cutting, aspen

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1841 **Variation in growth and adaptation among Norway spruce provenances**

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(1) Institute of Dendrology, Polish Academy of Sciences, Kórnik, Poland; (2) Poznan University of Life Sciences, Poznan, Poland; (3) Warsaw University of Life Science, Warszawa, Poland; (4) Forest Research Institute, Raszyn, Poland

Abstract: Finding suitable forest planting material becomes a challenge in a changing world. Yet, this problem may be tackled with the use of information about genetic variation in growth and adaptation. An important dimension of the IUFRO mission has always been the analysis and conservation of genetic variation in forest trees.
In this study we examined variation among 20 populations (provenances) of Norway spruce (Picea abies [L.] H.Karst) at the age close to half of rotation (40 - 44 years). We analyzed the most recent data on tree diameter collected at the common-garden experiment planted in 1974 at four sites. At each site we calculated basal area per hectare (BA) for each provenance. Data were standardized before analysis.
Significant variation among provenances was found for BA across four sites. Because of the incomplete design and mortality that occurred throughout the experiment we could not analyze the provenance × site interaction. However, the ranking of provenances according to BA varied by site. There were few provenances that performed constantly better (1) or worse (3) than average across all sites. These results point to a potential for selecting both planting material suitable for broad deployment, and locally adapted sources of Norway spruce in Poland.

adaptation; productivity; selection; tree breeding

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2314 **Effects of fruit maturity stage, seed coat, drying and storage temperature on Ximenia americana seeds germination in Laboratory**

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Abstract: Effects of fruit maturity stage, seed coat removal, drying, storage temperature and storage duration on Ximenia americana seed's germination were investigated in two experiments. Green, green-yellow and yellow fruits were collected in the South-West Burkina Faso and seeds extracted separately. In experiment 1, seeds were dried in silicagel at three target moisture content (MC) (15%, 10%, 5%), prior to germination. In experiment 2, dry seeds were stored at 35 °C, 18°C, 4°C and -20°C for 24 to 56 months. Moisture content (MC) and Germination and were assessed every six months. The collected data were analysed using a General Linear Modelling approach.

Seed coat removal improved the germination of green and green-yellow extracted seeds (24 to 62% and 64 to 68%, respectively). Drying did not really affect seeds viability, however dried seeds (4.18% MC) extracted from green fruits germinated at 58% when sown intact and at 68% when decoated. Dried seeds extracted from green-yellow and yellow fruits, stored at 4 °C germinated at 80-84% up to 50 months of storage.

We concluded that X. americana seeds were desiccation tolerant and orthodox. Seeds could be harvested at their green-yellow stage and decoating could be a pre-sowing treatment.
However, when store at 35°C, 18°C and -20°C, seed's lifespan is about nine months. We deducted that dry X. americana seeds may be sensitive to freezing cold storage (-20 °C), suggesting that they may belong to the intermediate class, an assumption which contrast with our findings and those of previous authors. We concluded that X. americana seeds even they were orthodox, they have an unusual storage behaviour which seems a bit complex but comparable to that of Cuphea species, whose storage behaviour depends on the seed's oil composition, particularly the triacylglycerol composition. Therefore, there is a need for further investigations in order to clarify their storage behaviour

Desiccation sensitivity, storage temperature,

Poster Exhibition Wednesday

121 - Reforestation challenges: planting material, ecophysiology, biodiversity, climate change mitigation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2446 **Afforestation trial with poplar and other tree species in an abandoned agricultural land of Piedmont hills (Northern Italy)**

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Abstract: In hill environments, the gradual abandonment of agricultural soils, due to urbanization, can lead to land degradation; the afforestation may be a solution. In an afforestation trial, established at Rosignano Monferrato (AL) during winter 1985-86, eight poplar clones have been consociated with other species (wild cherry, European ash, south European ash, deodar cedar), to evaluate tree growth and consociation effects on wood quality and soil properties. A randomized complete block, with 5 replications for poplar and 10 for the other species, was utilized as experimental design. The tree spacing was 5.65 × 5.65 m. Weeds control and pruning were applied during the first 10 years. According to the WRB classification, soils are Calcaric Cambisols (Loamic). In the study area, characterized by sub-alkaline soils, poor in organic matter and with a silty clay loam texture, the best results were obtained for the poplar clone 'Zero', with 100% of survival and production in volume (first 5 m of stem) of 100 m3 ha-1. Among the other tree species, cedar and cherry trees showed satisfactory and nearly stable results of growth and survival. The tree consociation had positive effects on stem quality: in particular, the trunks of cherry tree showed the best shape.

afforestation, hill, growth, soil organic carbon

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1378 **The influence of initial density on survival and growth of Scots pine - results from 32-year-old Nelder experiment**

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(1) Forest Research Institute, Sekocin Stary, Raszyn, Poland

Abstract: Initial planting density have a great influence on growth and mortality of individual trees. The aim of the study was investigation how survival rate, diameter, height and height-diameter ratio of 32-years-old Scots pine were affected by initial growing space. Data were obtained from two Nelder experimental plots located in south - eastern part of Poland.
The analysed growth area of a seedling varied between 0.16 m2 and 8.4 m2, corresponding to the initial density of 62,645 units/ha to 1,187 units/ha.
Survival rate substantially increased with increasing initial growing space - from 10% to 93%. The research demonstrated a significant effect of the plant spacing on the development of the thickness of pine stems over thirty years of their lifetime. Its value grew as the tree growth area increased in the scope analysed - from 5,9 cm to 15,1 cm. The plant spacing also affects the height of pines; however, this influence is not so significant as in the case of the diameter at breast height. Loosely spaced trees are slightly taller than those that are more closely spaced. At the age of 32 years, the tallest trees have initial growth area of 1 do 3 m2. An increase in the growth area beyond this value no longer affects tree height.
The height - diameter ratio significantly decreased with increasing initial growing space. The average values ranging from 80 to 173. The sufficient number of trees for silvicultural selection (trees with slenderness index not higher than 100) occurs at densities 7770 trees/ha and lower.

Scots pine, Nelder experiment, initial density

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1338 **Seedling Quality in Serbia - Results from a Three-Year Survey**

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Abstract: During a three-year survey in 15 forest nurseries in Serbia we measured seedlings of 19 species and 83 stocktypes of both conifers and broadleaves. Seedlings were measured in the nurseries for height and diameter, and subsamples was taken for measurements of shoot and root dry weight, root volume and presence of ectomycorrhiza. Our results show that current minimal requirements for plantable seedlings as defined by Serbian standard for hardwood seedlings quality SRPS D.Z2.112 (i.e., official document by Institute for Standardization of Serbia), are easily to achieve by cultural practice in nursery and that these standards should be updated. We found ectomycorrhiza on seedlings root from almost every nursery, seedbed and tray. Results of mean values and variation of measured morphological attributes are presented. The effect of nursery cultural practices to seedling quality is discussed.

seedling quality, morphological attribute, nursery

Poster Exhibition Wednesday

121 - Reforestation challenges: planting material, ecophysiology, biodiversity, climate change mitigation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2796 **Survival, growth, and N changes in transplanted ornamental seedlings under weed competition in urban soils**

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Abstract: Weeds showed greater growth and tend to generate higher competition on newly planted trees in urban soils compared in rural ones. Larger seedlings are widely accepted to have better ability to compete with weeds, but evidence in urban environment is insufficient. In the present study, two species of slowly growing tree seedlings, Buddhist pine (Podocarpus macrophyllus) (PM) and Northeast yew (Taxus cuspidata) (TC), were cultured under contrasting photoperiods in 2014 and transplanted to pots filled with urban and rural soils in 2015. Compared to weeds in rural soils, those from urban soils had greater shoot and root biomass (P=0.0723 and 0.0728, respectively), resulting in the decline of survival of TC. Growth response to soil types were species specific and BM seedlings had greater height (P=0.0002) and RCD (P<0.0001) but less root length (P=0.0491) in urban soils than in rural ones. First-year photoperiod-induced larger seedlings mainly had greater initial height at transplant and greater height increase after transplant for both species. Large BM seedlings in urban soils gained the greatest biomass increase in 2nd-year shoot (P=0.0003) and root (P=0.0015). Seedlings in urban soils suffered more decline of N concentration in shoot for both species (BM, P<0.0001; TC, P=0.0046) resulting in the general decline of shoot N content. Larger transplanted BM seedlings had less N content increase in shoot. However, no N changes were related to weed biomass. In conclusion, the effect of weeds on newly planted trees was species specific and it mainly accounted for the survival of TC. After the establishment of transplanted seedlings, weeds had no effect on their growth in a year-long term. First-year photoperiod can continuously promote shoot growth in transplanted BM seedlings but meanwhile impact their N uptake. Seedlings in urban soils were larger but weaker as N utilizer compared to them in rural ones, which had no business with weed competition.

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168 - Sustainable forest operations - A foundation of the green economy

KG II - HS 2121 (Uni Freiburg)

IUFRO17-473 **Site level evaluation of traffic and soil disturbance after cut-to-length harvesting**

Talbot, B.* (1); Pierzchala, M. (1); Astrup, R. (1)

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Abstract: Cut-to-length (CTL) harvesting involves the use of a harvester and forwarder to fell, process and extract roundwood timber to roadside. The need for a consistent supply of timber to the wood industry implies that operations sometimes have to be carried out when soils are not at their most resilient e.g. during rainy periods or the spring thaw. Although CTL technology is generally seen as being environmentally preferable to skidding, the risk of site damage is increased under these conditions as loaded forwarders have gross masses of 30-40 tonnes and can cause compaction or rutting. Obtaining a detailed map of the condition of the post-harvest site can be beneficial in (i) identifying whether any areas require urgent amelioration (ii) planning and prioritising amelioration work (iii) following up on vegetation growth in compromised areas, and (iv) in increasing awareness of soil bearing capacity and environmental impacts amongst machine operators.
This paper demonstrates the outcomes of using unmanned aerial vehicles (UAVs) for the mapping and monitoring of machine trails in post-harvest stands.

UAV, wheel rut, post-harvest, logging, environment

Poster Exhibition Wednesday

90 - Advanced Methods for Measuring, Monitoring and Assessing Forests to Meet Societal Challenges

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1270 **Structure-based forest management**

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Abstract: Structure-based forest management (SBFM) is a novel forest management approach whose primary goal is to achieve a healthy and stable forest ecosystem by the mean of optimizing the stand spatial structure. Forest spatial structure are quantified and adjusted by spatial structure parameters. These parameters include species mingling (M) for describing species spatial segregation, neighborhood comparison (U) for describing size difference of individual trees, uniform angle index (W) for describing horizontal distribution pattern of individual trees, and crowding index(C) for describing the crown overlapping degree of a neighborhood unit. SBFM have been successfully applied to different forest regions. Result showed that after SBFM, the crown density of stand, the dominance of climax species, species diversity and the forest spatial structure had been improved, the annual increase in forest growth per hectare was 1.4 cubic meters higher than the control. It is largely further developing and quantifying the management principles of the "Near-nature Forest Management" to avoid management risks effectively. The Structure-based Forest Management may be a simple, easy to operate, scientific approach for the sustainable forest management.

Spatial structure, Stand structure parameter, SBFM

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2159 **Measuring tree diameters with close-range photogrammetry**

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Abstract: Information and measurement technologies are developing fast, which also influences forest monitoring concepts. New advanced methods are tested for measurement of tree growth and forest resources. Diameters at different heights are measured in forest inventory as they describe stem taper and allometry and are therefore essential input to estimte tree volume and biomass.
A widely known and often tested monitoring technique to measure tree parameters is Terrestrial Laser Scanning (TLS). In contrast, this study focusses on Close-Range Photogrammetry (CRP) approaches and compares them with a remote diameter measurement tool and a caliper as reference. The measurements were done for 50 trees in south eastern Norway with: (1) images taken with two reflex cameras mounted on a stereo rig (RCS), (2) images taken all around trees with a single reflex camera handheld (SRCH), (3) a Criterion dendrometer (CRD).
Main processing steps for CRP data including image matching, point cloud creation and scaling were automated using Python in Agisoft. Diameters were measured in the generated 3D dense point clouds using open source software and compared with results from the other devices. With RCS method images from 27 out of 50 trees could be matched and scaled using the known camera distance with satisfying result. Wheras with SRCH images from 43 out of 50 trees could be matched but only 22 could be scaled with the help of an uncoded marker (chessboard) until now. Random and systematic deviances of the measurements based on the different methods will be compared and discussed. The CRP data is promising, as the level of detail in resulting point clouds is similar to data generated by TLS.
However, the number of images taken and the measurement process itself need to be optimized to save storage capacity and time in most forest inventory settings. Additionnally and even more important, image aqcuisition has to be improved to increase the quality of generated 3D point clouds.

Close-range photogrammetry, diameter, inventory

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2842 **Data, data everywhere: Detecting spatial patterns in fine-scale forest health data collected across a continent**

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Abstract: Fine-scale forest health data collected across broad regions are becoming increasingly available. Presenting this information in ways that are relevant for policy and management decisions is critically important, but poses a major challenge. Appropriate geographic analyses of these data can help identify locations of forest health concern. We present one such approach, Spatial Association of Scalable Hexagons (SASH), which identifies locations where ecological phenomena occur at greater or lower frequencies than expected by chance. This flexible approach is based on a sampling frame optimized for spatial neighborhood analysis, adjustable to the appropriate spatial resolution, and applicable to multiple data types. We divided portions of the United States into scalable equal-area hexagonal cells and, using three types of data (field surveys, aerial surveys, satellite imagery), identified geographic clusters of forested areas having high and low values for (1) invasive plant diversity and cover, (2) mountain pine beetle-induced tree mortality, and (3) wildland forest fire occurrences. This method is a "big data" analysis tool with potential application for macrosystems ecology studies that require rigorous testing of hypotheses within a spatial framework. It is a standard component of annual national reports on forest health status and trends across the United States and can be applied easily to other regions and datasets. These analyses are useful for understanding macroscale patterns and processes associated with each forest health threat, for assessing its ecological and economic impacts, and for identifying areas where specific management activities may be needed.

Big data; Ecological monitoring; Spatial clusters

Poster Exhibition Wednesday

90 - Advanced Methods for Measuring, Monitoring and Assessing Forests to Meet Societal Challenges

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1604 **Optimisation of a Forest Management Field Trial Design Using Stand State Characteristics: A Case Study of a Platycladus orientalis Plantation Field Trial in the Xishan Mountains, Beijing, China**

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Abstract: Field trials are an integral part of forestry management, and the design of a field trial determines its precision. However, no one trial design ensures consistency between treatment and control groups. In this study, a Platycladus orientalis field trial on a plantation in the Xishan Mountains, Beijing, China, is presented to demonstrate a new field trial design method to optimise forest management field trials. A completely random optimisation design based on stand state characteristics was compared with traditional methods including simple sequence design and Latin square design. We showed that a new completely random optimisation design based on stand state characteristics ensured consistency under the stand conditions in the trial. This optimisation design approach can be implemented using two methods depending on the trial goals. Method 1 is used when spatial structure parameters are the primary focus of a study, while method 2 is used when spatial structure parameters and basic parameters of the stand are of equal importance in a study. F-values for ANOVA test of the spatial structure parameters and the basic parameters were less than F0.05 for both methods, indicating that the spatial structure parameters and the basic parameters were not statistically different between the stand structure adjustment and non-adjustment groups in the trial. This trial design method improves the precision of field trials, providing a basis for rational evaluation of the effects of different forestry management practices.

forest management, field trials

Poster Exhibition Wednesday

197 - Ecosystem services and the well-being of forest-dependent communities: enhancing social

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3299 **Community participation as key component to value ecosystems services: A case study of the protected forest reserve of El Quinini, Colombia**

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Abstract: Ecosystem'services valuation is a complex and controversial task; however, it is important to decision making related to ecosystem management. Around the world there are several ecosystems inhabited by farmers who directly or indirectly benefit from ecosystems'services. The protected forest reserve El Quinini (PFRQ) is located in the Andean region of Colombia, an important hydrological zone of the country. Therefore, when seeking strategies to manage the reserve two components are important to consider, water and people. This study aimed to estimate the value of the water resources for the inhabitants of the reserve. To accomplish this the study was divided in three steps, first we identified people's perception about conflicts associated to water in the PFRQ, interviews, field trips, meetings, a an social cartography were used. Then, with the information obtain from the previous step a set of possible strategies were valued in economic terms. Finally, a contingency valuation is performed to estimate downstream habitants'willingness to pay if people downstream.

Community members who live upstream proposed forest restoration, agroforestry, and community workshops as strategies to maintain a constant flow of water. The estimated economic value of those activities is around 400 thousand US dollars. Currently, we are collecting data to make the contingency valuation analysis, expected results will be obtained in March 2017.

Community participation, Ecosystem services

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3718 **Forest tenure holders' willingness to participate in forest carbon sink projects: a case in China**

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Abstract: China has been promoting forest restoration and forest protection since 1970s. Recently forest sequestration has been recognized as a national strategy of climate change mitigation. The government of China has initiated 7 pilot carbon markets to facilitate the climate change mitigation policy. Forest carbon offsets credits are a part of the pilot carbon market portfolio. Along with collective forest tenure reform basically completed, forest carbon enterprise must strengthen the cooperation with forest tenure holders in the implementation of forest carbon sink projects, which are based on "company + forest tenure holders" cooperation. Forest tenure holders have become the most important participants for forest carbon sink project. Now China has developed 9 official and 1 pilot forest carbon sink projects, including Lin'an moso bamboo forest carbon sink project in Zhejiang Province and Fangshan carbon sink afforestation project in Beijing. Although these two projects are pioneers, these are different from each other in term of ecological, socio-economic and cultural conditions. Yet very little is known about characteristics of forest tenure holders including their willingness to participate in forest carbon sink project and their cognition about forest carbon sink. Understanding forest tenure holders' willingness to participate in the forest carbon sink project is important not only for project's implementation but also its effects. The aim of the study is to identify factors influencing forest tenure holders' willingness to participate in forest carbon sink project and the cognition of people about forest carbon offset project. The study can provide the government and investors with the information on the behavior and attitude of local forest tenure holders, which is important to design forest carbon sequestration policy and investment decision.

Carbon sink, forest tenure holders' participation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1907 **Carbon forestry to enhance social innovation for the well-being of European mountain regions**

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Abstract: Importance of European mountain ecosystems to provide carbon regulation ecosystem service has been overlooked long time resulting in marginalisation of European mountains. The specific role of mountain ecosystems, predominantly consisting of boreal and temperate forest as well as temperate grasslands, in climate change regulation arises from their capacity to capture more than 70% of world carbon in vegetation and soil organic matter in the long term. Nowadays, mountain sustainable development is top policy agenda in UN SD agenda 2030 and also implementation of Paris Agreement 2015. In this paper, we address the potential of carbon forestry as an innovative technological-governance practice to respond to global climate impacts. Following understanding of social innovation as new and reconfigured social practices in response to challenges associated with societal, economic or environmental dimension (Horizon 2020 Project SIMRA), we analyse the potential of common pool forest resource regime to promote social innovations. We argue that carbon forestry common pool resource regime is capable to mitigate CO2, increase resilience as well as well-being of European mountain regions. Empirical evidence in our paper is comparative analyses of eight forest management regimes in European continental mountains and Northern Europe applying expert assessment to determine factors influencing the vulnerability and resilience of forest regimes and estimate the intensity of used carbon forest management practices. Based on carbon sequestration potential of forest regimes and social value of sequestered carbon calculated, we determine optimal adaptation policies.

carbonforestrycommons social innovation wellbeing

Poster Exhibition Wednesday

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-3402 **The Study on Integrated Water Resources Management in Thailand: A Case Study of The Mae Klong River Basin.**

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Abstract: Thailand has 25 river basins with 254 sub-basins. The Mae Klong River is a river in western Thailand, begins at the confluence of the Khwae Noi or Kwai Sai Yoke and the Khwae Yai River or Kwai Si Sawasdi in Kanchanaburi, passes through Ratchaburi Province and empties into the Gulf of Thailand. These rivers support the irrigation for Thailand's agricultural economy. The major problems of the Mae Klong River Basin are water shortages or drought, flooding or flash floods, water quality, environmental problems, and management problems.
Integrated water resources management is a combination of the economic, social, and environmental dimensions of water management with the aim of getting the greatest value from water use under a system of sustainable development. Quantitative data on the relevant organizations, institutions and sectors were collected using questionnaires and qualitative data were collected from stakeholders at all levels using the tools of community forums, participatory workshops, and experimental study.
The results revealed about the major components of the integrated water resources management system including creating an environment that facilitates water resources management including: policies, river basin plans and strategies into practice. What is needed is efforts to promote understanding, to publicize information, to set learning curricula and to undertake more research at the policy level and local level in order to bring about greater knowledge and understanding of the related water management issues among the general public, students, and private sector organizations. Also, a database should be set up for the Mae Klong River Basin. This will create an environment that facilitates effective water resources management.

integrated, water resources management,Mae Klong,

Poster Exhibition Wednesday

29 - Integrating climate change, disturbances and diversity effects into growth models: from understanding

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3762 **Effect of diversity on forest productivity**

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(1) Université du Québec à Rimouski (UQAR), Rimouski, Canada; (2) AgroParisTech, Paris, France; (3) Ministère des Forêts, de la Faune et des Parcs, Québec, Canada

Abstract: Close-to-nature forest management has received a lot of attention in recent years, by promoting both structural and species diversity. Both types of diversity influence various stand dynamics such as tree growth, mortality and recruitment, in addition to various interactions within the stand. Under certain conditions, mixed-species forests can be more productive than monocultures. The availability of different resources, a better use of canopy space through niche partitioning or the increase of forest density in mixed stands can all explain this increase in productivity. In order to adjust to the knowledge acquired by a better understanding of the ecological processes, the structural and mixing interactions must be integrated into growth models. Using data from permanent plots from Québec forests, the mixing effects on tree growth, mortality and recruitment will be established and then adapted in light of this knowledge. With the results obtained, silvicultural scenarios based on the mixing effects in order to help forest managers to maintain forest productivity and decrease forest vulnerability to large-scale disturbances.

diversity, growth models, mixing effect

KG II - HS 2121 (Uni Freiburg)

IUFRO17-760 **Applications of transition matrix models in forest dynamics in Amazon rainforest in Brasil**

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Abstract: The study of forest structure and dynamics is important for the conservation and sustainable use of forest resources. We examined the dynamical processes of tropical forest, which was submitted to sustainable management, and a forecast of its future development was found by applying the technique of Transition Matrix. The data correspond to 14 permanent plots from one compartment belonging to areas of forest logging, in Amazonas-Brazil. The measurements of all the trees were realized before logging in 1996, and after logging in 1998 and 2001. Measured data in these three continuous inventories were abundance, basal area, volume, recruitment, and mortality. Potential consequences of logging on dynamics and forest composition are briefly discussed. Forest showed a negative balance in the observed periods; namely, mortality was superior to recruitment. Using the data of the last two measurements we made projections of diameter distribution, number of surviving trees, and number of dead trees per diameter class for the next years: 2004, 2007, and 2010. The forecast for these years maintained the trend observed in the measured data, but dynamics of this forest is too complex, needing a more careful analysis, for instance a study of the environmental changes.

forest dynamics, logging, Transition Matrix

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2958 **Integrating forest disturbance of nun moth into process-based growth modelling.**

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Abstract: Often, future forest growth studies are driven by climatic & edaphic factors and by silvicultural management only, neglecting the fact that biotic damages play a major role in future forest growth dynamics. We integrated an existing model approach of several biotic disturbance impacts into the process-based forest stand model *4C*. In this framework, insects and pathogens are clustered upon their damaging action and abstracted on the level of functional groups (e.g. defoliators). The validation of the extended model is based on observed impacts of a nun moth (*Lymantria monacha*) gradation (2004) in two pine stands in Brandenburg, Germany. That gradation data set encompasses yield measurements, the tree mortality induced by the gradation and tree ring growth data. The latter one was used to evaluate the impact of the observed defoliation on the tree ring increment simulated with the model *4C*.
Results at the stand level are discussed with respect to the sensitivity of modelled growth dynamics and mortality due to defoliation. At the tree level we evaluate the capability of the applied model approach to account for changes in the tree ring dynamics. Last, we will provide an outlook on model validations with respect to other tree species and/or pathogens of other functional groups (xylem-, phloem-, fine root-disturber).

model validation, biotic impact, defoliation

Poster Exhibition Wednesday

29 - Integrating climate change, disturbances and diversity effects into growth models: from understanding

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2176 **The role of large trees in the biomass production of heterogeneous forest**

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Abstract: In heterogeneous forests, large trees retain a substantial amount of above ground biomass, but their annual contribution to biomass accumulation remains unclear. A modal relationship between tree growth and tree size is traditionally expected. But recently, it has been demonstrated that the rate of tree biomass accumulation continuously increases with tree size supporting the metabolic theory of ecology. To clarify the role of large trees in biomass production of heterogeneous forest, we used data of tree growth, mortality and recruitment monitored during 20 years in 10×4-ha plots in a species rich and structurally complex tropical forest (Central African Republic). Biomass gains and losses were analyzed in relation to the abundance of large trees and by tree size classes using a bootstrap procedure. At the plot level, the accumulation of biomass in large trees was generally lower than that accumulated in small trees. The high mass growth rate of few large trees was therefore outbalanced by the growth of the numerous small trees. Moreover, the loss of biomass due to the mortality of few large trees could be substantial, and rarely outbalanced by the accumulation of biomass in these large trees. The annual net accumulation of biomass significantly decreases with the initial abundance of large trees.

Tree growth, heterogeneous forest, large trees

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1068 **Unraveling soil effect on overyielding of species mixture in forests of the Netherlands**

Lu, H.* (1); Condés, S. (2); del Rio, M. (3); Mohren, F. (1); den Ouden, J. (1); Schelhaas, M.-J. (1); de Waal, R. (1); Goudiaby, V. (1); Sterck, F. (1)

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Abstract: A growing number of studies provide evidence that mixed-species forests often, but not always, have higher stand productivity than monospecific forests (referred to as overyielding). In this study, we explored how overyielding depends on the combination of mixed species and on soil fertility in Dutch forests. Firstly, we hypothesized that fast-growing species would dominate the stand and cause overyielding because the complementary resource use allows them to acquire soil resources more effectively and achieve more effective carbon gain at full exposure. Secondly, we expected that the complementary effects of the fast-growing dominant species and this overyielding would be stronger on more fertile soils. We evaluated our hypothesis by analysing five species Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), common beech (*Fagus sylvatica* L.), Scots pine (*Pinus sylvestris* L.), common oak (*Quercus robur* L.), and silver birch (*Betula pendula* Roth) growing in Douglas-fir-common beech, Scots pine-common oak, common oak-common beech, and common oak-silver birch mixtures from 398 permanent field plots all over the Netherlands. We found that two mixtures, i.e. Douglas-fir-common beech and Scots pine-common oak showed overyielding both on low and medium water availability and this overyielding was largely attributed to the admixture of Douglas-fir and common oak, respectively. The common oak-silver birch mixtures underyielded on low water availability and overyielded on medium water availability, whereas the common oak-common beech mixtures had no mixture effect. The results do not support our hypothesis since overyielding was not always driven by fast-growing species and also do not agree with the stress-gradient hypothesis because overyielding effect was similar on different soils. We conclude that the growth of one species benefits from the admixture species, and that soil water is not a factor limiting overyielding under the conditions as studied in the Netherlands.

Mixing effect; Soil water availability

KG II - HS 2121 (Uni Freiburg)

IUFRO17-648 **Disentangling species mixture effects on individual-tree growth using Swiss National Forest Inventory data**

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Abstract: Ecological processes driving the dynamics of forest ecosystems are greatly influenced by species diversity. In recent years, a lot of attention has been given to the comparison between mixed and monospecific stands, often showing a higher productivity in mixtures than in monocultures. However, mixing effects can vary strongly depending on climatic conditions, resource availability and stand development. Possible effects of tree species mixtures have rarely been considered in individual-tree growth models, which are pivotal tools for assessing forest development under environmental changes.
We used Swiss National Forest Inventory data to incorporate mixing effects into species-specific growth functions of the empirical scenario model MASSIMO. These functions include the influence of stand and tree characteristics, release effects due to harvesting, nitrogen, site topography and climate on tree growth. We integrated categorical predictors accounting for plot-level mixtures in the nonlinear mixed-effect models to analyze interactions between mixture and other predictors. In a second step, we implemented continuous variables such as species-level basal area of larger trees and stand density index, and assessed their predicative power to improve the models.
Although we detected positive influences of some categorical mixtures on tree growth, mixing effects for most species were observed to be negative. Often, these effects were significant only in interaction with other predictors, confirming the need to carefully account for stand density, climatic variation and soil resources when investigating complementarity. Continuous variables, however, corroborated the findings and improved the performance of the growth functions for most considered tree species, although their effect size varied among the species. The new functions will be implemented in the scenario model for better predicting forest development in response to changes in climate and species composition.

mixed forests; growth functions; species diversity

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29 - Integrating climate change, disturbances and diversity effects into growth models: from understanding

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3945 **Integrating disturbance agents into the Tree and Stand Simulator (TASS): a case study of stem rusts on lodgepole pine**

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(1) British Columbia Ministry of Forests, Victoria, Canada; (2) College of New Caledonia, Prince George, Canada

Abstract: Forest managers are interested in connecting the incidence of forest pathogens to impacts on volume at rotation age. Models which simulate the effects of pathogens on trees are, therefore, essential and find application within tree growth simulators. We present models developed for use on lodgepole pine affected by western gall rust (Endocronartium harknessii [J.P. Moore] Y. Hiratsuka), within the province of British Columbia, Canada. A Markov multi-state model describes how individual trees transition between states of healthy, infected and dead. A second model is used to determine the location and size of galls on individual trees at rotation age. Development and testing of the models was performed using data from long-term experimental plots with various levels of western gall rust. The models were programed into the Tree and Stand Simulator (TASS), which is the provincial government's growth simulator for managed stands. Projections of pure and mixed species stands were run and evaluated against actual data and biological expectations. The results of these tests suggest that when the incidence of western gall rust is high, severe volume losses at rotation are likely. We conclude with a discussion on the application of the rust modules in TASS when determining allowable annual harvests.

managed stands tree model lodgepole pine pathogens

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IUFRO17-1731 **Inter- and intra-species competition: modelling the effect of natural regeneration ingrowth in a plantation growth and yield simulator**

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Abstract: Plantations in Eastern Quebec have a lot of natural regeneration ingrowth, where the planted species represents on average only 60% of the growing stock. Forest managers must thus evaluate how to maximize their past investments, all the while having to respect their obligations to carry out close-to-nature management. New thinning methods have thus been proposed to convert the plantations into irregular/uneven-aged stands. In order to help decision makers, a single-tree growth model was developed. The growth function can either be spatially explicit or implicit. The best competition index was species dependant, whereby the growth of ingrown balsam fir was better predicted by a spatially explicit competition index and the growth of planted white spruce and broadleaved natural regeneration was better explained by the basal area of the trees larger than the target tree. Competition was also divided by clade: broadleaved species were found to reduce the growth of the planted species more than coniferous competitors. Clade separation of the competition did not however improve the fit statistics of the growth model. During the initialisation phase of the model, the number and size of the non-merchantable stems are predicted using a diameter distribution model, if these trees were not measured. The number of non-merchantable broadleaved trees increases with the number of merchantable broadleaved species. On the contrary, the number of non-merchantable trees of both balsam fir and white spruce decreases with their merchantable counterparts. The simulator was validated using an external database, yielding very small bias. Initial model simulations indicate that although broadleaved ingrowth reduces neighbouring coniferous species, the reduction in growth is not important at the stand level. Moreover, if the objective is to increase stand complexity such as required by close-to-nature silviculture objectives, several entries will be required.

close-to-nature, growth model, forest diversity

Poster Exhibition Wednesday

36 - Interactions of Global Forest Resources and Climate

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1456 **Interactions of global forest resources and climate**

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Abstract: Forest ecosystem and climate is strongly connected. Forest growth and production is influenced by global climate change. All disturbances depend on environmental conditions and have interactions. Climate has a huge impact on forest dynamics and it is very important to monitor global warming and changes in the ambient air. It is necessary to examine the carbon dioxide concentration increases and its effect on the current situation. Also it is need to measure water vapour and interactions between CO2 and H2O.

The carbon dioxide and water vapour were measured by the eddy covariance method. Measurement station is located in Estonia, J ärvselja and equipment is installed on the middle of the clear-cut area. Eddy covariance installation has been there several years already and data is recorded 24 hours, detecting time trends. This particular work is about data analysis which was obtained in 2014 and 2015. The main reference period is the end of May and beginning of the June on both years.

Turbulent covariance method makes it possible to measure the CO2 and H2O flows and other meteorological variables. The method is suitable for measurement during successive years more consistently in order to monitor variables of forest ecosystems. Method must be used so that all the potential factors for the correct measurements are involved and elimination of the side effects must be sure (so that they do not distort the data).

It was concluded that the difference has been in flux in different years. Major role in the differences can be the temperature difference and the cloudy weather. Year 2014 temperatures were higher and weather was more sunny, which is reflected by photosynthesis intensity. We also have to consider influence of respiration. Release of CO2 and absorption of CO2 will give us main components to build the model of carbon budget.

Eddy covariance, carbon dioxide, CO2 and H2O flows

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1641 **Regional implication of diversified forest management actions on forest carbon stock**

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(1) University Freiburg, Freiburg, Germany; (2) Biodiversity and Climate Research Centre (Bik-F), Frankfurt am Main, Germany

Abstract: We study the regional implication of detailed forest management actions on the forest carbon stock in Baden-W ürttemberg (BW, Germany) with the dynamic vegetation model LPJ-GUESS. Forest management in BW features a wide array of regional diversification with the goal of a sustainable, multifunctional and close to nature forest management. Regional forest service, i.e. ForstBW, has already developed the state-wide guidelines for different forest stands, with similar structure and similar management objectives, to ensure the implementation of appropriate management actions. As LPJ-GUESS features a detailed representation of the vegetation carbon fluxes and, therefore, it allows us to simulate the regional differences in management activities and their effects on the forest carbon stock. For this study we parameterized the most common tree species in BW to simulate regional forest growth and developed a forest management module for LPJ-GUESS on the basis of the major ForstBW guidelines. These guidelines encompass a list of age-dependent silvicultural interventions for each WET (stand development type) and according BET (Intervention type). This study shows that a complex dynamic vegetation model as LPJ-GUESS, which is widely used for modelling vegetation growth on a European or global level, can be used to represent forest growth, forest management and the effect on carbon stocks on a local level as effective. Cumulative effects of diversified management actions in a forest landscape on carbon stock can though be analysed in details.

reg. forest mgmt, carbon stock, DGVM, LPJ-GUESS

Poster Exhibition Wednesday

19 - The role of forests in sustainable rural development in developing countries: livelihoods and quality of

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3735 **Forest management significance to local industry based on input-output model for Chrzanow Forest District**

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Abstract: The importance of forest management in economy in local level has increased recently. That justify researching the relation between forestry and local economic circle. The forest management's economic impacts were examined using input-output models. These models are useful for defining the linkages, and the degree of interdependency, between forestry and local economy. That linkages represented by the tables and indicators calculated show value of forestry importance in local economy.
The presented research shows the calculation methodology and analysis of the indicators structure frame based on input-output analysis. Presented research is also based upon the hypothesis that money and materials were transferred from Forest District to another local businesses. Research was conducted in Chrzanow Forest District. That analysis was used to determine how scale of economic activity in forestry influenced the change in structure of the linkages between Chrzanow Forest District and economy sectors. This study has examined the Chrzanow Forest District economic activity at the regional level in 2006-2015, and has provided comparisons within the regional economy.

forest management, input-output analysis,

KG II - HS 2121 (Uni Freiburg)

IUFRO17-697 **Cutch (Acacia catechu) resin production in Myanmar and its socio-economic benefits**

Tani, Y.* (1)

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Abstract: The aim of this study is to illustrate how a forest product directly contributed to the local producers' and trader's income, and indirectly to the rural area's social welfare, through a case study of Cutch resin production in Myanmar. First, I will describe how Cutch resin was produced. Then, I will analyze the socio-economic influence of this activity. Finally, I will discuss about the sustainability of this business.
Literature was collected at the Forest Department (Nay Pyi Daw. FD) and Forest Research Institute (Yezin) in 2014 and 2015. Interviews were carried out using a questionnaire, in 2015.
Cutch resin has been produced in this area for more than seventy years. Now it is produced under a network of a trader and resin producers. The trader obtained licenses from the FD for the trees, and the FD collected royalty from the trader. The producers made resin blocks and sold them to the trader. Thus, the FD, the producers, and the trader earned revenue and income, and the trader had invested part of his income to build a private hospital. However, all the trees were natural and the demand was growing, so the management might become more important to sustain this business.

forest product, Myanmar, socio-economic benefits

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3338 **Local Community Network Empowerment for Prevention and Protection of Coastal Erosion in Laem Fa Pha Sub-District, Samut Prakan Province, Thailand**

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Abstract: Coastal erosion is a major problem in Thailand. It affects public and government properties, as well as the socio-economy of the country, including emigration in coastal communities, loss of habitats, and decline in fishery production. To combat the problem of coastal erosion, projects utilizing bamboo sticks for coastal defense against erosion were carried out in Ban Khun Samutmaneerat, Laem Fa Pha Sub-District, Phra Samut Chedi District, Samut Prakan Province by Marine and Coastal Resources Department. Local Community Networks is involved in this project.The objectives were to 1) increase the efficiency of community network management in coastal prevention and protection, 2) create a management guideline of Laem Fa Pha community network fund for prevention and protection, 3) increase Laem Fa Pha community network members' competency for coastal prevention and protection. The research was a participatory action research in Laem Fa Pha sub-district alongside coastal zone of Samut Prakan Province. The information compiling based mainly on the participation among community leaders and community network members via household visiting, group discussion, seminar, study tour and particular planned activities. Information was analyzed by the researchers, community network members in Laem Fa Pha sub-district, Samut Prakan Province and representatives from agencies concerned.The research revealed that 1) the community management network in coastal prevention and protection efficiency could be increasing by formulate Laem Fa Pha community network's regulations together with administrator committee structure revising. 2) regulation for Laem Fa Pha community network fund management should be formulated and 50,000 Baht should also be initiated as community network fund. 3) in order to increase the competency of coastal prevention and protection network members', study tours to Chon Buri, Rayong and Chanthaburi provinces have to be formulated.

community networks, coastal erosion, empowerment

Poster Exhibition Wednesday

146 - Climate change and air pollution impacts on forest health status and productivity

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1767 **Climate response of Norway spruce (Picea abies (L.) H. Karst) and Silver fir (Abies alba Mill.) in virgin forest of Northern Velebit**

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(1) Czech University of Life Sciences in Prague, Prague, Czech Republic

Abstract: As part of an international project ,,*Mixed severity disturbances as drivers of structural variability and carbon dynamics at the stand and landscape levels*,, this presentation describes the problematics of growth and development of Norway spruce (*Picea abies* (L.) H.Karst.) and Silver fir (*Abies alba* Mill.) in virgin forests of Smrceve doline on Northern Velebit. The presentation describes the connection of tree-ring growth with climate changes in the last few hundreds of years.
The concept and history of dendrochronology is described as well. Using the methodology of dendroclimatology, tree-rings are compared to climate data to investigate their variability and mutual connection. Tree-rings are cross-dated to confirm the dating of each tree-ring and reference chronologies of spruce and fir are developeded using CDendro programing tool.
Years of extreme growth (pointer years) are investigated as well.
Secondary statistical check of cross-dating and measurements is done in *COFECHA* program.

Concerning the time period of available climate data (CRU TS - 1901.-2015.) and the replication issues (EPS and r-bar), mean residual reference chronologies developed in *ARSTAN* program are compared to climate data (temperature and precipitation) in a time period of the last 115 years.

Response function analysis shows negative correlation of temperature respone of tree-rings in July and August for Norway spruce, while showing positive correlation with precipitation in July.

For Silver fir, the response on temperature is positive in November of previous year and Febuary of current year, while showing positive correlation on precipitation in July and negative in April.

Dendroclimatology, climate change, tree-rings

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1362 **Volatiles released from Chamaecyparis formosensis and Chamaecyparis obtusa var. formosana in response to light intensity and growth temperatures**

Chen, Y.-J.* (1); Huang, Y.-L. (1); Yeh, T.-F. (1); Chang, S.-T. (1)

(1) National Taiwan University, Taipei, Taiwan

Abstract: *Chamaecyparis formosensi*s Matsum. and *C. obtusa* var. *formosana* Hayata, both are premier coniferous trees and dominant in montane cloud forest in Taiwan. However, their distribution ranges are different. Many researches have compared the characteristics of these two species, but their volatile organic compounds remains unknown. The emissions of mono-/sesqui-terpene from these two species were studied in four day/night temperatures (15/13 °C, 20/15°C, 25/20°C, and 30/25°C) with natural light. In *C. formosensis*, α-pinene was the predominant compound emitted in 15/13 °C, 20/15°C and 25/20°C, while the emission of β-ocimene increased significantly in 25/20 °C and 30/25°C and became the major compound emitted in 30/25 °C. In *C. obtusa* var. *formosana*, the main compounds emitted were sabinene, β-myrcene, and thujopsene. The lowest emission rates of total terpenes were found in 15/13 °C and increased with increasing growth temperatures, and monoterpenes emitted more dramatically than sesquiterpenes. However, the diurnal fluctuation of total terpenes emission was mainly correlated with the fluctuation of light intensity. In conclusion, the predominant terpenes of these two species were different. Total terpenes emitted more in higher temperature while diurnal variation of terpene emission were modulated by the light intensity.

Taiwan cypress;BVOCs;temperature;light intensity

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1200 **Comparative analyses of growth, gas exchange characteristics, and chlorophyll fluorescence of three dominant boreal tree species during the vegetation season in hemiboreal zone, Lithuania**

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Abstract: Current climate scenarios predicts rising air temperature along with increasing frequency and intensity of summer drought for Central and Eastern Europe during the upcoming decades. Severe drought episodes affect physiological processes in trees such as transpiration, photosynthesis and carbon allocation. This may lead to reduced primary productivity and even forest stand decline. Understanding gas exchange between plants and the atmosphere is important in woody plant research. The different levels of spatiotemporal integration are usually investigated by the tree radial growth, leaf gas exchange measurements, and micrometeorological methods. The study was conducted in Aukstaitija integrated monitoring station, Lithuania. The dominant trees: Betula pendula, Pinus sylvestris and Picea abies were selected for the investigation. Seasonal growth, leaf (needles) gas exchange and chlorophyll fluorescence was measured during the vegetation season and showed relation with meteorological of parameters, especially in the episodes of summer droughts.

deciduous trees, climate change, coniferous trees

Poster Exhibition Wednesday

146 - Climate change and air pollution impacts on forest health status and productivity

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2015 **Changes in phosphorus supply of the spruce stands in the northern mountains of the Czech Republic**

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Abstract: Long-term effect of sulphur emission on the forest stands and soils in the past and high nitrogen deposition today affect stand nutrition, mainly in northern mountain ridges of CR. The contribution shows changes in phosphorus supply in long-term investigated spruce stands in Luzické, Jizerské and Orlické Mts. on the border between the Czech Republic and Germany and Poland. Crown defoliation, taking needles and soil samples, their analyses were carried out according to standard ICP Forests methodology.
During the last ten years low phosphorus concentrations were measured, often under the deficiency limit (1,2 g P/kg), and N/P ratio exceeding the optimal range (6-12), mainly in the second needle year class. Values of N/P ration between 12-18 in Jizersk é Mts., and between12-27 in Luzické Mts. were found out. Low phosphorus amount was stated also in mineral soil horizon.
With respect to health status (crown defoliation) all the spruce stands investigated are of similar condition, crown defoliation is ranging between 20 to 25%. Changes of N/P ratio and P concentration in the needles are more significant for the spruce stands in Jizersk é and Luzické Mts. Decreasing P availability and growing N/P ratio in needles indicate problems with P supply for the spruce stands in most of the plots investigated in the near future. Up to date, changes of P supply are not reflected in the health state of forest stands, in spite of that, N/P ratio can be used as a fast indicator of the nutrition balance of the spruce stands.

N. spruce, health state, foliar anal., N/P ratio

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1372 **Analysis of adaptive capacity of Croatian Mediterranean forests to climate change by using various indicators of tree and stand vitality**

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(1) Croatian Forest Research Institute, Jastrebarsko, Croatia; (2) Norwegian Forest and Landscape Institute, Ås, Norway

Abstract: Mediterranean forests in Croatia account for 24% of total forest area. Although they are of small direct economic value their social and ecological functions are very important (preservation of soil, air, water and biodiversity; carbon sequestration; impact on microclimate conditions; aesthetic and touristic function etc.).

Tree vitality or condition can be defined as the ability of a tree to assimilate, to survive stress and to react to changing conditions. Several factors have been recognized to influence tree vitality, and the reasons for the deterioration of tree condition can be found in specific interactions of stress factors. Since the knowledge on the condition of Mediterranean forest ecosystems in Croatia is insufficient, the goal is to determine the spatio-temporal variability in condition of forest ecosystems through the use of various indicators (increment; tree mineral nutrition; crown defoliation; multispectral satellite images), taking into account soil characteristics, elevation, inclination, exposition and climate influences.

Our plan is to use UNECE-ICP Forests large-scale (Level 1) plot network to utilize existing data (crown condition) and to obtain new data on relevant indicators (tree nutrition, increment). The field data will be complemented by the analysis of data from various information sources such as E-OBS gridded dataset based on ECA&D information.

Spatial and temporal data from terrestrial research, remote sensing and external sources will be analysed in order to establish cause-effect relationships among various vitality indicators and climate properties. The overall objective of the project is to determine the current adaptive capacity of Croatian Mediterranean forests to climate change and to model the adaptation of those forests to different climate change scenarios.

tree nutrition, defoliation, modelling, increment

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KG II - HS 2121 (Uni Freiburg)

IUFRO17-3828 **Observed changes of site conditions driven by climatic extremes**

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Abstract: Observed tree mortality of the last decades has shown that the vulnerable forest ecosystems are especially affected by the recurrent, long lasting droughts, heat waves and their consequences. From all site factors climate is changing the fastest, extreme events can be the largest threatening factor in the 21st century. Beyond climate, other soil characteristics are playing a conditioning role.
The aim of our research was to investigate the ongoing and projected change of site conditions that are considered to be of primary importance in terms of tree species selection. For a case study region in Hungary (Keszthely Mountains, near to Lake Balaton) climate tendencies have been determined for the period 1961-2100, as well as a detailed soil sample analysis has been carried out covering 100 sites.
In the last decades a 0.8 degrees increase of temperature and a 6-7 % decrease of the precipitation has been observed locally for the summer months. Until the end of the century decrease of the summer precipitation sum may exceed 25 % compared to the period 1981-2010, the probability of extreme hot days may double. Potential soil loss is high due to generally shallow soil profiles (rendzinas). The amount of accessible water for trees (Scots and Austrian pine, sessile oak and beech) is limited, especially in case of intense precipitation events. Health condition decline has been observed however also in stands on more favourable brown forest soils at the same location. These tendencies combined with biotic damages (Armillaria spp) can be the reasons of ongoing forest mortality.
It is an urgent need to rethink tree species selection considering the changing climate in order to maintain forest health and ecosystem services.

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climate extremes, site conditions, mortality

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1970 **Advancing Quantitative Understanding of Urban Forest Carbon Sequestration and Climate Mitigation**

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Abstract: Urban ecosystems generate up to 70% of annual greenhouse gas emissions. However, urban vegetation and soils are capable of sequestering substantial quantities of carbon. Soil total organic carbon (TOC), total nitrogen (TN), and soil respiration (SR), and multiple biophysical indices were investigated across six 50m2 study sites in the central United States, including a rural forest (UHF), bottomland hardwood forest (BHF) and four intra-urban sites. Urban sites contained the greatest TOC and TN from 0-35 cm with 15.81 kg TOC m-2 and 960.57 g TN m-2 and 22.78 kg TOC m-2 and 1262.41 g TN m-2 for an older neighborhood and parking area (PA), respectively. The BHF contained 7.64 kg TOC m-2 and 637.62 g TN m-2 and the UHF contained 7.11 kg TOC m-2 and 639.61 g TN m-2 from 0-35 cm. Average growing season SR rates across sites ranged from 7.96 umol m-2 s- at the UHF to 12.92 umol m-2 s- at the PA site. Total estimated carbon storage was largest at the BHF (38,990.2kg) and smallest at a bottomland floodplain grassland site (15.9kg). Results show that urban areas may have the potential to sequester more C and N than wildland counterparts.

Urban Forests, Soil Respiration, Carbon, Nitrogen

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IUFRO17-583 **Effect of copper and silver nanoparticles on growth of selected species of pathogenic, wood decaying and mycorrhizal fungi in vitro.**

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Abstract: Metal nanoparticles seem to possess antimicrobial properties. Some studies indicate that they can be used in plant cultivation as fungicides. On the other hand, some fungal strains might be stimulated by metal nanoparticles. The aim of the study was to determine the effect of copper (CuNPs) and silver (AgNPs) nanoparticles on growth of pathogenic, wood decaying and mycorrhizal fungi in vitro. Eight species of fungi were selected for the study (10 strains): two pathogenic species (3 strains) - Rhizoctonia solani 5648.01 and 1195.00, Fusarium oxysporum, three wood decaying species - Pleurotus ostreatus, Merypilus giganteus, Sparassis crispa, and three mycorrhizal species (4 strains) - Amanita citrina, Suillus luteus and Hebeloma crustoliniforme W40 and 111/08. The cultures of fungi were grown in Petri dishes on three media: PDA (pathogenic fungi), malt agar (wood decaying fungi), Melin-Norkrans (mycorrhizal fungi). Four concentrations of nanoparticles: 5 ppm, 15 ppm, 25 ppm and 35 ppm were applied. The studies have shown different effects of CuNPs and AgNPs on radial growth of tested species' mycelia. S. luteus was stimulated by both nanoparticles except the highest concentration of CuNPs. S. crispa was characterized by lack of sensitivity. Growth of other species was restricted to various degrees. H. crustuliniforme was inhibited the most. AgNPs caused stronger inhibition of pathogenic and wood decaying fungi's growth than CuNPs. For both H. crustuliniforme and R. solani species, significant differences were found in each strain's sensitivity to both CuNPs and AgNPs. The experiment has shown that CuNPs and AgNPs can be used as an alternative to fungicides only for some species of pathogenic and wood decaying fungi. However, consideration must be given to the fact that growth of some mycorrhizal fungi might be inhibited.

nanoparticles; alternative fungicides

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1485 **How do Different Mature Pinus taeda Families Respond to Root-infecting Fungi?**

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Abstract: Root-feeding bark beetles and their fungal associates Leptographium terebrantis and Grosmannia huntii are the biotic factors associated with root-infection. This study was conducted to understand the susceptibility of four mature Pinus taeda L. families to these root infecting fungi. Two mature families which were found to be susceptible and two families which were found to be tolerant to these fungi in a previous seedling screening study were used. Two primary lateral roots were excavated from each tree and artificially inoculated with either L. terebrantis or G. huntii along with a control. Eight weeks following inoculation, host responses were recorded as length of lesion and vascular occlusion. Both fungi caused lesion and occlusion upward and downward from the point of initial inoculation. Families screened showed different levels of susceptibility to the fungal species tested, as indicated by their average lesion length. The susceptibility and tolerance of mature tree families to L. terebrantis and G. huntii were congruent with the results of seedling families. In summary, the same pattern of family difference exists in mature as well as in immature stages of loblolly pine.

root disease, loblolly pine

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1857 **Infection biology of the rust pathogen Uromycladium acaciae**

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Abstract: The South African wattle industry, centred on *Acacia mearnsii* (black wattle), produces wood chip and bark extract exports worth more than US$150 million pa. This economically important industry is, however, threatened by a severe emerging disease caused by the rust pathogen *Uromycladium acaciae*. To facilitate resistance screening and disease risk modelling and forecasting, germination studies and artificial inoculation experiments were conducted to identify the optimal environmental conditions (temperature, light and dew period) for infection. Teliospores and urediniospores germinated between 5-30 °C, with an optimum at 15-25°C. Basidiospores were produced and germinated at temperatures between 5-25 °C, with an optimum at 15-20 °C. The effect of light on germination was inconsistent. At 20 °C, germination of all spore types completed after 6-24 hours. If teliospore germination was interrupted by a dry period of 1-2 hours, basidiospore production was significantly reduced, even when teliospores were re-wetted. Infection of *A. mearnsii* seedlings was observed with a dew period as short as 6 hours, but the most severe disease symptoms resulted from a dew period of 48 hours. *Uromycladium acaciae* was able to infect only young, expanding plant tissue. These results provide a first step towards controlling this extremely damaging rust disease.

Pucciniales, disease triangle, climatic niche

Poster Exhibition Wednesday

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IUFRO17-2433 **Financial performance of stump treatment against Heterobasidion sp. in Norway spruce dominated forests, the case of Finland**

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Abstract: Heterobasidion annosum species are one of the most destructive pathogens in the boreal coniferous forests causing root and butt rot. Primary spread to healthy stands is with basidiospores landing and germinating on fresh wood tissue. Hence, the pathogen benefits from forestry as stump surfaces offer optimal conditions for new infections. Secondary mycelial spread via root system to living trees establishes the disease in the stand. However, chemical and biological control solutions can be sprayed on stumps as the trees are cut down to inhibit the primary spore infections. This study aimed to analyse the economic profitability of stump treatment as a control method against Heterobasidion root rot. Various scenarios of spore density and stump treatment quality were simulated for two Norway spruce stands in Finland with a mechanistic model Hmodel. New infections were controlled during the final cut of the previous tree generation and the profitability was estimated based on the net present values (NPV) of the next tree generation. Simulation results showed that the stump treatment is profitable especially in scenarios were the spore density is high and there are no previous infections in the stand. In addition, the quality of the control affected the probability significantly.

root rot, control, stump treatment, profitability

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3639 **Are yellow sticky traps a good methodology to evaluate the insect pest community associated with an Eucalyptus plantation?**

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Abstract: Some *Eucalyptus*-feeding insect species have left Australia and established in new sites causing economic losses. The development of methodologies to early detect these pests is required to reduce the damage generated by them. The aim of this study was evaluate the use of yellow sticky traps (YST) to analyze the insect pests associated with a *Eucalyptus* spp. plantation in Itamarandiba Minas Gerais, Brazil. Were installed 138 yellow sticky traps, monthly changed during march to june of 2016, in a area with *Eucalyptus saligna* Sm. seminal, three *Eucalyptus cloeziana* F. Muell. clones (A,B,C) and *Eucalyptus camaldulensis* Dehnh. Were captured 37673 individuals of five *Eucalyptus* pest: *Leptocybe invasa* Fisher & LaSalle, *Glycaspis brimblecombei* Moore, *Thaumastocoris peregrinus* Carpintero & Delapé, Thrips and *Phoracantha recurva* Newmann. Thrips (N=18424) and *L. invasa* (N=11883) were the most abundant. Only *L. invasa* presented significant differences in the average of the catches per trap of Clone A with the others (pK-W= 0.05). Cluster analysis separated *E. saligna* from the other and grouped the *E. cloeziana* clones with *E. camaldulensis* (Coph index=0.753). The yellow sticky traps were important to detect the invasion of *T. peregrinus* to the plantation and the presence of *P. recurva*, only species that wasn't observed damage. Future prospects will be to evaluate the optimal number of yellow sticky traps and population fluctuation of *Eucalyptus*-feeding insects throughout the year. Acknowledgments: PROTEF-IPEF, APERAM Bioenergia.

commercial plantations, pests, forest health

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1898 **Screening for Alnus glutinosa genotypes resistant to Phytophthora × alni**

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Abstract: The aggressive oomycetes *P. ×alni* infects *A. glutinosa* of riparian forests in high numbers in Germany. Symptoms include yellowing, sparse foliage, early fall of leaves and cankers, with exudates forming tar spots on the bark. Cambium necrosis and decreasing vitality result in decline or death. In Germany application of chemicals is not authorised in natural habitats and forests, so on-going alder decline results in high economic and ecological losses.
This project aims for: the development of a reliable test system for screening the susceptibility of alders, the identification/propagation of resistant genotypes and the study of the infection process. Selected trees should improve seed orchards and forests. Initially, alders resistant to high pathogen pressure were selected in the Oderbruch region. Alders were micro-propagated and used *ex vitro* in infection experiments. In a 2nd approach, alders were grown from seeds obtained from 17 seed orchards. Alder genotype resistance was evaluated in greenhouse experiments. Five *P. xalni* isolates were applied to experimentally damaged bark or non-wounded bark.
Preliminary results indicate the overall high susceptibility of the evaluated material. Inoculation of wounded alders resulted in up to 100% infection rates without correlation to genotype (selected clones) or origin (seed-orchards). This result is not only influenced by the forced experimental design. It should be considered that selected trees showing field resistance under high pressure might reflect more a decreased local infection-risk in a plot rather than the incidence of resistant genotypes. Experiments in progress simulate a more natural infection of non-wounded alders.
The identification of resistant genotypes is needed urgently with respect to the particular ecological niche of alder, the prominence of the pest and global warming reducing the frost period limiting the spread of the pathogen.

Alnus glutinosa, Phytophthora, resistance

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IUFRO17-3380 **Quantifying the impact of wattle rust (Uromycladium acaciae) on black wattle (Acacia mearnsii) growth in South Africa**

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(1) ICFR, Scottsville, South Africa; (2) NCT, Pietermaritzburg, South Africa; (3) FABI, PRETORIA , South Africa

Abstract: Wattle rust, caused by Uromycladium acaciae, is a new disease reported in 2012/13 affecting black wattle (Acacia mearnsii) plantations in South Africa. This rust fungus has been known in South Africa for more than 20 years, but without causing significant disease. Possible reasons for the change in disease severity, the epidemiology and the likelihood of yield losses are under investigation. A study was initiated to determine the impact of U. acaciae on black wattle growth and to relate the interaction between wattle rust and co-occurring insects on trees. Three exclusion trials were implemented to quantify the impact of the disease. The trials were laid out as completely randomized block design in a 4 x 4 factorial combination. The factorial combination consisted of a control, fungicide (azoxystrobin and difenoconazole), insecticide (cypermethrin) and fungicide + insecticide. Fungicide application significantly reduced disease severity (by 82%) and improved tree growth by 38%. Upon application of insecticide, no significant differences were observed. This was similar for the fungicide and insecticide combination treatment where no statistical differences were observed with the application of insecticide. Wattle rust has a negative impact on tree growth. The results will be further investigated to effectively quantify the disease impact and contribute towards developing an integrated pest management strategy for the wattle rust.

wattle rust, wattle insects, yield

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IUFRO17-1354 **Bacterial leaf blotch in Uruguay, etiology and management of a new threat for eucalypts plantations**

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Abstract: Plant pathogenic bacteria can cause wilt, dieback, shoot and stem blight, as well as leaf blotches and blight on Eucalyptus spp. During surveys conducted in Uruguay between 2008 and 2012, defoliation associated with bacterial leaf blotches and blight was observed. The aim of this study was to identify the bacterial species associated with this disease and to determine the possibility for management through selection of resistant genotypes. A total of 36 bacterial strains associated with leaf blotches were collected countrywide. Each strain was tested for hypersensitivity and pathogenicity in detached leaves of E. grandis and E. dunnii. Pathogenic strains were identified by biochemical and molecular techniques. Aggressiveness of six selected strains was characterized by artificial inoculation on E. grandis seedlings. The three most aggressive strains were selected to evaluate resistance of E. grandis and E. dunnii genotypes. The strains were identified as Xanthomonas axonopodis, Pseudomonas syringae, Erwinia psidii and Pantoea eucalypti, associated with bacterial leaf spot, being X. axonopodis the predominant species. Variability in aggressiveness among strains was found, being three strains of X. axonopodis the most aggressive ones. Significant differences were also found in resistance among Eucalyptus genotypes. Our results will assist breeding programs selecting for genetic resistance against this disease.

Eucalyptus diseases, genetic reistance

KG II - HS 2121 (Uni Freiburg)

IUFRO17-378 **Molecular characters of endophyte fungi isolated from Paraserianthes Falcataria in Indonesia**

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Abstract: Paraserianthes falcataria (sengon) is a fast growing species that commonly cultivated in community forests in Indonesia especially in Java. The biggest problem of its cultivation is an attack of pathogenic fungi Uromycladium sp. that causing gall tumor. Previous studies revealed that some individuals of sengon planted in seed orchards were potentially resistant to this disease although genetic diversity of this species is considered low. The effective method for controling this disease is currently unavailable. Studies on woody trees indicated that some endophytic fungi may play some roles in the trees resistance and may also enhance the trees growth. A diversity study with proper species identification of endophytic fungi inhabit sengon may provide important information on the species that have such roles.This is a preliminary study to observe the diversity of endophyte fungi of sengon and to obtain isolates for study its potential as biocontrol agent againts Uromycladium pathogen and its potential as growth enhancer. Endophyte fungi was isolated from leaves, twigs, leaves stem and barks of sengon originally from Papua planted in seed orchards in Java. At least 27 species of fungi were isolated from this study, Fusarium spp and Diaporthe spp. are the most isolated fungi. Some fungi isolated from sengon are known pathogens on other host plants and some fungi reported to have bioactive compounds. The isolates and sequences of rDNA ITS of this study will be used as references for further studies to investigate the role of these fungi on the susceptibility of sengon to gall rust disease and the potential for growth enhancer. A corresponding study will also be conducted to observe the genetic diversity of Uromycladium in Indonesia to obtain best management practice in the controlling the disease.

endophyte fungi, biocontrol, identification

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IUFRO17-3922 **Chemical and biological control of plant pathogen, Fusarium species in forest nurseries**

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Abstract: Plant diseases need to be controlled to maintain the quality and abundance of food, feed and fiber produced by growers around the world. Fusarium causes blight, wilt and root rot in numerous economically important plants. For the chemical control three fungicides Devicopper, Kavach and Thiram were tested against the pathogens Fusarium solani, Fusarium avenicum and Fusarium moniliforme. The concentration taken was 0.05%, 0.1% and 0.2%. The maximum inhibition was observed in conc. of 0.1% in the case of Devicopper and Kavach while in Thiram maximum inhibition was observed in 0.05% concentration for each species of Fusarium. On the basis of following result we can conclude that Thiram is the most promising chemical control to control the growth of Fusarium species. The microorganism used for biological control was Trichoderma harzianum, inoculated with the test fungus Fusarium solani, Fusarium moniliforme, Fusarium avenicum on one end of the culture plate while the biocontrol agent Trichoderma harzianum, on the other side of the plates. The antagonist Trichoderma harzianum showed highest percent inhibition against pathogen Fusarium avenicum followed by Fusarium moniliforme and Fusarium solani. On the basis of following result we conclude that Trichoderma harzianum is a good antagonist and Biocontrol agent for Fusarium spp.

Biological Control, Fusarium, Trichoderma

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IUFRO17-2689 **Can Melastomataceae endophytes be a threat to Eucalyptus plantations in Colombia?**

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Abstract: The plant trade between countries allows endophytic fungi to be transported undetected in healthy plant tissues. Commercially planted *Eucalyptus* are threatened by latent pathogen such as the endophytic Cryphonectriaceae. Host shifts between Melastomataceae and Myrtaceae by different species of Cryphonectriaceae has increased the host range of these pathogens. The aim of this study was to identify the species of Cryphonectriaceae in five native hosts from Colombia and two introduced from Brazil and to identify the potential origin of plant pathogens on *Eucalyptus*. Healthy branches of native Melastomataceae were collected from five provinces in Colombia, and then incubated between 2 to 4 weeks to stimulate growth for fruiting bodies of the Cryphonectriaceae. The isolates were identified based on DNA sequence data from two gene regions. This study is the first to determine whether endophytic fungi from Melastomataceae in Colombia are a source of different canker diseases in *Eucalyptus* plantations. Interestingly, *Aurapex penicillata, Chrysoporthe inopina* and *C. cubensis* were isolated from different species of Melastomataceae in Colombia. This has severe implications on quarantine programs regarding the movement of latent, endophytic pathogens in plant material.

Cryphonectriaceae, Host shift, Endophyte

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3069 **Investigation of Fungal Diseases associated with Acacia mangiumin Forest Plantations in Hoa Binh province, Vietnam**

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Abstract: Acacia mangium plantations in Vietnam are suffering from serious diseases such as anthracnose, die-back and many others. This leads to reductions in quality and quantity of A. mangium plantations. This study investigated fungal diseases associated with A. mangium forest plantation in Hoa Binh province and compared their damages between young and old plantations. The results of identification based on morphological features of fungus spores and fruit bodies show that there were five pathogenic fungi found in the study area. Disease incidence and disease index of fungal diseases were different between two age classes. Ceratocystis wilt caused by Ceratocystis manginecans with disease index of 1.12 and disease incidence of 34.42% was identified as a main pathogenic fungus in young plantation while Fusarium wilt caused by Fusarium euwallacea with disease incidence of 52.02% and disease index of 1.05 was identified as a main disease species in old plantation. To manage these pathogens, bacterial endophyte was used. Bacillus subtilis LC strain was isolated from the cambium of A.mangium twigs and it had the antagonism against test fungi including C. manginecan and F. euwallacea.

Acacia, Antifungal, Fungal diseases, Vietnam

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IUFRO17-3430 **Biological control of chestnut blight by induced mass conidia production of hypovirulent isolates of Cryphonectria parasitica on excised chestnut stems**

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Abstract: The fungus Cryphonectria parasitica is the causative agent of chestnut blight. A group of DsRNA viruses causing the phenomenon hypovirulence, render the fungus less virulent. Hypovirulence is naturally disseminated, but also successfully used as a control method of this devastating plant disease.
We used excised chestnut stems as substrate for mass production of hypovirulent conidia of C. parasitica. Perforated stems, to xylem depth, were autoclaved, inoculated with hypovirulent conidial suspension, and incubated until formation of abundant active pycnidia protruding pycnospores through the perforation holes. These were attached to chestnut trees, above and below active chestnut blight cankers, induced previously by inoculation of virulent isolates of C. parasitica. We sampled treated cankers 90 days later.
Viral dsRNA was isolated from 19 isolates representing converted cankers (hypovirulent). For 10 isolates sequence analysis revealed no differences in any base pair of the CHV1 ORF A region, when compared to the treatment isolate J12, indicating conversion by the isolate on the excised chestnut stems with mass conidia. The remaining 9 samples with 1 or more base pair difference in the ORF A region from our treatment isolate J12, apparently have been converted by local hypovirulent isolates.

C.parasitica, hypovirulence, biological control

Poster Exhibition Wednesday

191 - Nitrogen deposition: spatial-temporal change and ecological impacts

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3906 **Reduced and oxidized nitrogen and sulfur deposition from Los Angeles smog to urban and wildland areas**

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Abstract: Annual throughfall deposition (Oct. 2010 to Oct. 2011) within the Los Angeles (LA), California Air Basin varied widely across the urban coast to the desert gradient, from 10 kg N ha-1 at Barton Flats in the eastern San Bernardino Mountains (SBM) to 104 kg ha-1 in central LA. Deposition of N in the urban and suburban sites were all > 60 kg ha-1 yr-1 and deposition at Camp Paivika, a forested site in the western SBM was 90 kg ha-1 yr-1. Throughfall deposition of SO4-S was higher than expected in some sites, with fluxes ranging from 2.1 at Tanbark Flats to 40 kg ha-1 yr-1 in south Los Angeles. The throughfall data represent deposition directly under mature trees. Deposition fluxes across the landscape accounting for varying canopy cover would be lower. These high levels of N and S deposition have resulted in N saturation responses and reduced soil pH values in chaparral and forested areas of the LA Basin. Likely sources of S emissions include shipping near major seaports, large transport trucks, trains, oil refineries in south LA, as well as urban traffic. The percentage of inorganic N deposition in throughfall as NH4+ ranged from 19 to 56% across the gradient, with increasing percentages at sites further from the urbanized areas. Throughfall deposition fluxes of NH4-N ranged from 4 - 38 kg N ha-1 yr-1. Such high inputs of NH4-N suggest that important sources of NH3 emissions in the LA Basin may be unaccounted for or underestimated. Ratios of NH4-N:NO3-N in wet deposition at the Tanbark Flats monitoring site near Los Angeles are increasing, suggesting that NH4+ will constitute a greater fraction of total N deposition from urban source areas in the future.

reactive nitrogen, sulfur, throughfall, trends

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3580 **Mapping of areas with potential effects of high loads of nitrogen and surface ozone in Czech forests**

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Abstract: Nitrogen deposition and ambient ozone remain to be the major threats for forests. We present a spatial analysis for both nitrogen deposition and ambient ozone levels in Czech forests. The input data are ozone concentrations and nitrogen deposition measured during a long-term monitoring program run by the Czech Hydrometeorological Institute, the period under review is 1993-2015. Our aim is to indicate the hot spots where combined effects of elevated ozone concentrations and elevated nitrogen deposition are to be expected. Moreover, we analyze to what extent are these hot spots variable in time.

nitrogen load, ambient ozone, spatial pattern

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2997 **Determining the total nitrogen deposition to forests - A spatio-temporal comparison of canopy budget models across Germany**

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(1) Thünen Institute of Forest Ecosystems, Eberswalde , Germany; (2) Northwest German Forest Research Institute, Göttingen, Germany; (3) Landesamt für Natur, Umwelt und Verbraucherschutz NRW, Recklinghausen , Germany; (4) Sachsenforst, Competence Centre Wood and Forestry, Pirna , Germany

Abstract: Quantifying total deposition of nitrogen to forest ecosystems is essential for both forest health related research and policy advice. For example, the exceedance of critical loads in forest ecosystems is an important criterion for the success or failure of clean air policy and a source of information in the context of licensing procedures as well as risk assessments for the European habitat directive. While wet deposition of nitrogen in open field and throughfall can be measured directly, dry and occult deposition is typically estimated using one of various models. Based on deposition measurements at 82 intensive monitoring sites in Germany during the period 2000-2014, we compared common canopy budget models regarding their estimates for total nitrogen deposition. The objective of this study is to analyze the spatial and temporal variability between model estimates and to quantify their dependence on different influencing factors (e.g. tree species, climate conditions, lowlands and mountainous sites). We will provide information under which conditions and to what extent the choice of the method affects estimates of total nitrogen deposition to forest ecosystems. In addition, these findings may be of relevance for uncertainty estimation in nitrogen budget calculations.

Canopy budget, Nitrogen deposition, Uncertainty

Poster Exhibition Wednesday

191 - Nitrogen deposition: spatial-temporal change and ecological impacts

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3682 **Total deposition of nitrogen in Swiss forests: comparison of assessment methods and long-term changes**

Thimonier, A.* (1); Kosonen, Z. (2); Thöni, L. (2); Schmitt, M. (1); Seitler, E. (2); Waldner, P. (1)

(1) Swiss Federal Institute WSL, Birmensdorf, Switzerland; (2) FUB - Research Group for Environmental Monitoring, Rapperswil, Switzerland

Abstract: Throughfall and open-field precipitation (bulk deposition) have been continuously sampled at 14 Swiss forest sites since 1995 or later. These measurements allow the atmospheric deposition of air pollutants such as sulphur (S) and nitrogen (N) to be assessed. Combined bulk deposition and throughfall measurements can quite reliably quantify the wet and dry deposition of S, with dry deposition being obtained from the difference between throughfall and bulk deposition. However, they only provide an underestimation of the dry deposition of N, as this element is readily taken up by the forest canopy and the throughfall flux of N is therefore reduced accordingly. Additional low-cost complementary measurements can help to better assess N deposition. We measured air concentrations of ammonia (NH3) and nitrogen dioxide (NO2), the two main compounds that contribute to dry N deposition, using passive samplers at selected sites in 2000 and 2014. We then estimated the dry deposition of N using the inferential method, in which deposition velocities are applied to the measured concentrations. The deposition estimates obtained with the throughfall method (using assumptions to estimate the fraction of N retained by the canopy) and the inferential method compared generally well. The comparison of the two sampling campaigns of 2000 and 2014 showed a decline in deposition, a result which was strengthened by the general decrease at all sites where long-term measurements of bulk deposition and throughfall were available. In spite of the observed decrease, the current N deposition is still within or above the empirical critical loads for N in most regions except in the high elevated Central Alps.

nitrogen, inferential method, throughfall

Poster Exhibition Wednesday

174 - Connecting People to Forest Science: Innovative Communication Approaches for Delivering Science

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1578 **Public Science, Public Health, and Public Policy: A Case Study of Lessons Learned from Portland Moss and Air Quality Study Communications**

Sands, Y.* (1)

(1) U.S. Forest Service, Pacific Northwest Research Station, Portland, United States

Abstract: In February 2016, Portland, Oregon, USA was rocked when news broke of two air pollution "hotspots" located in the heart of the environmentally friendly city. The source of the findings was a novel and not-yet-published U.S. Forest Service study that explored the ability of a common species of Pacific Northwest moss to serve as a biological indicator of air pollution. In the days and weeks following the media publication of the preliminary findings--which found that moss concentrations of a toxic and potentially carcinogenic heavy metal, cadmium, were 49 times higher than Oregon's state benchmark in the hotspots--the communications landscape was complex and intense. Residents living near the hotspots were angry, frightened, and distrustful of government and regulators; media were focused on identifying how the pollution occurred and why it went unchecked; and state regulatory agencies were interested in learning how to best incorporate the findings into their official response. Follow-up instrumental air-quality monitoring by the state corroborated the moss concentration maps and models and confirmed the scientists' findings of alarmingly high levels of the heavy metal in the city's air. U.S. Forest Service communicators responded to these varied communication needs via a two-pronged approach--first by sharing and contextualizing the study's preliminary findings and, later, by empowering citizens, news media, and agency partners. Communication methods ranged from interpersonal and media outreach and news releases to an informational website, interactive "story map," audio press conference, and list serv. Collaboration, transparency, and citizen engagement were key to the success of this effort and its lessons may prove useful in other situations where forest science profoundly affects people's lives.

Science delivery, communication, public engagement

KG II - HS 2121 (Uni Freiburg)

IUFRO17-113 **Is anybody listening? Ways to track and analyze your social media impact.**

Hayes, J.* (1)

(1) US Forest Service, Rocky Mountain Research Station, Fort Collins, United States

Abstract: Have you ever wondered who is seeing your Twitter posts about that new paper you just published? Have you thought about who is following the new Facebook page you created for your research partnership? There are ways to find out - it's called social media ANALYTICS (and it's free)!

Social media analytics are growing in popularity and can tell you how many people saw your post, how many people opened the link to your paper, who shared your posts, and more. Also, for Facebook page's you can see what countries your followers are from and their age demographics.

This poster will demonstrate how to find and track your social media impact on Twitter and Facebook (and it's free). It will also highlight a variety of social media mechanisms scientists can use to help make their research more visible online for various audiences and demographics (e.g., submitting pieces to The Conversation, getting profiles on major outlets liked LinkedIn or ResearchGate, etc.).

social media, analytics, reach, Facebook, Twitter

Poster Exhibition Wednesday

63 - Forests for the Health of the People

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3890 **How forests impacts human health - media perceptions from Germany**

Hentze, T. (1); Kleinschmit, D.* (1); Selter, A. (1)

(1) University of Freiburg, Freiburg, Germany

Abstract: In the last years an increasing interest of the media in the issue of forests and their impact on human health can be observed. What kind of storyline is told in the media reporting on forests and their linkage with health is an empirical questions. This presentations aims to answer this question by presenting empirical results from an analysis of German print media. Three major categories build the basis of this analysis: (i) human health, (ii) forest context and (iii) actors. The results of this analysis show what kind of health issues are presented as being affected e.g. by taking a walk in the forests. They furthermore show the picture of forests presented in the media as having positive impact on health and they identify the actors involved in the issue of forest and human health.

Poster Exhibition Wednesday

26 - Policy learning across governance levels for durable results

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3029 **The role of education and research organizations in fighting corruption and illegal activities in forestry: example from Serbia**

Rogelja, T.* (1); Shannon, M. (2); Petrovic, N. (3); Tomicevic-Dubljevc, J. (3)

(1) University of Padova, Department of Land, Environment, Agriculture and Forestry, Legnaro (PD), Italy; (2) University of Freiburg, Faculty of Environmental and Natural Resources, Freiburg, Germany; (3) University of Belgrade, Faculty of Forestry, Belgrade, Serbia

Abstract: According to the European Parliament, the Western Balkans remain a region where corruption and illegally logged timber are high when compared to European Union countries. A first step in insuring the legal harvesting of wood is to eliminate corruption. Our paper addresses the challenge of the incorporation of anti-corruption measures into Serbian forest policy in the period 2010 - 2013. We employed structural network analysis to identify the key forest policy actors involved in the incorporation of anti-corruption measures. Surprisingly, it seems that neither scientific nor educational organizations were structurally connected to actors involved in the incorporation of anti-corruption measures. Although respondents from the research and education organizations recognized the importance of issue of corruption and its connection with illegal logging, they did not believe that they could influence the either the content of or the measures and processes of incorporation of anti-corruption measures in the forest sector. Without knowledge creation and diffusion among research and education actors within the network of forest sector actors, innovations and policy learning are less likely to occur.

education and research, anti-corruption, SNA

Poster Exhibition Wednesday

183 - Forest Education

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2874 **Gunung Walat University Forest : A Unique Transformation From Sufferer to Learner of Global Cimate Change Impact**

Ikhsan, M.* (1)

(1) Bogor Agricultural University, Bogor, Indonesia

Abstract: Gunung Walat Educational Forest (GWUF) was established in 1951 with the land was completely bare. In the past years, where highly Indonesia deforestation rates proofed by a state-owned timber company cleared the entire region and leaving behind other than mud. In 1959, plantation activities was done by forestry district and continued by students from Faculty of Forestry, Bogor Agricultural University. The total of forest area is 359 hectares which is surrounded by villages that villagers collaborate with forest administrator for agroforestry program. The goal of the research is to determine what the indicator from GWUF as sustainably-managed forest for climate change learning media and make GWUF as a success stories for forest management model in the world. This activities is using an identification of ecological and social aspect from GWUF that related with adaptation and mitigation program and build such as platform to promote how good integrated forest management of GWUF as a global model for forestry education. It is an uniquely transfromation how sixty years ago a muddy and bare forest changes into a good university forest as a learner how we build a good perspective in managing forest for the climate change in the future.

GWUF, climate change, forestry education

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1590 **Forest Education System and Human Resource Training for forestry in Japan : the historical change and the present situation**

INOUE, M.* (1); OISHI, Y. (1)

(1) Tama Forest Science Garden, Forestry and Forest Products Research Institute, Hachioji Tokyo, Japan

Abstract: Recently, in Japan, forest expert training is attracting attention. We analyzed the historical change and present situation of forest education and human resource training for forestry. There are 28 universities and colleges, 17 technical schools, and 72 vocational high schools with forest related courses (2016 present). Also, there are several training systems related to forestry, i.e. for forest workers, planners of forest management, and forester's qualification based on county agent of forestry. Concerning the history, forestry-specialized education started in 1882. In these days, forestry experts were needed, so many forestry educational schools were established. After a series of wars, education system was reformed in 1947. Production of timber for postwar restoration and reforestation were needed; and there were 25 universities and 102 high schools which had a forestry-course. However, since the 1970's, domestic timber product has been decreasing, and forestry education was reconstructed since the 1990's. Domestic timber product has increased again in the 2000's; therefore training systems have started based on high demands of forestry workers. So now, various training systems coexist. There is a necessity to reconfirm educational aims and contents concerning educational schools and training systems from the viewpoint of human resource training.

university, high school, extension, specialist

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3517 **The Global Outlook on Forest Education - A Joint IFSA IUFRO Task Force project**

Lackner, M.* (1); Rekola, M. (2)

(1) Austrian Research Centre for Forests, Wien, Austria; (2) Department of Forest Sciences, University of Helsinki, Helsinki , Finland

Abstract: The forest sector is globally under changes due to several drivers such as climate change, political instability, aging societies, new technologies, and bioeconomies. All these drivers have had considerable impacts on forests and the forest sector in general, and more specifically, on the required competencies of people working in this field. As a result new skills and state of the art knowledge are needed for those working in the forest sector. Because of the increased demand for social, management and governance skills among other generic competencies the educational environment has to adapt to stay competitive. To understand the changing demands of the forest sector and to investigate steps taken from education universities to find timely solutions, the Joint IUFRO IFSA Task Force is implementing innovative research methods.

The Global Outlook on Forest Education (GOFE) project has made a competence analysis with the human research specific Behavioural Event Interview (BEI) method. This method applies in-depth interviews that target recent graduates and documents their professional life needs. The aim is to reveal the needed critical skills, both forest subjects related and generic. The outcomes of the study are expected to enable comparisons across different countries and curricula, and potentially enrich the development of tertiary forest education perspectives, as well possible contribution for new Life long Learning courses in the forestry sector. The results are envisioned to contribute to the development of a more current approach to forestry education and a more dynamic view of the field.

forest education, competencies, human resources

Poster Exhibition Wednesday

183 - Forest Education

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3087 **Long-term image and audio monitorings of deep forests: toward environmental education and citizen science**

Nakamura, K.* (1); Saito, K. (1); Fujiwara, A. (2); Kobayashi, H. (1); Sezaki, K. (1)

(1) The University of Tokyo, Kashiwa, Japan; (2) The University of Tokyo, Yamanakako, Japan

Abstract: The Cyberforest research project is archiving the real forest environment with daily images and recordings. This digital archive could become an object of citizen science such as phenological observations, which would require both accessibility to the archives and a motivator for performing the observation. In this study, a website named "Cyberforest for Environmental Education" (CF4EE) was built and the effects of environmental learning as a motivator for citizen science involving digital archives were considered.
The contents of CF4EE are the following: (1) teaching materials for phenological learnings; (2) the newest still images, live sound links, and data from weather sensors; (3) links to archived images and recordings. Currently, six locations from deep natural forest to seashore across Japan are operative. Cameras, microphones, and compound weather sensor (temperature, humidity, wind direction, wind direction and velocity, and precipitation) record the data for storage in laboratories through the internet.
Long-term data of images, covering approximately two decades, are available in the archives for observing plant phenology in a mountain forest monitoring site. In this study, full bloom dates of Prunus verecunda and bud flush dates of Betula ermanii were observed by junior high school students. These observations were conducted as a part of environmental education about seasonal variation and climate change. They seemed to be a motivator for observation on the part of the students, whereas the quality of observations by students varied far too widely to qualify as data for phenological science. However, the authors considered that quality of observations by students were adequate for phenological learning. If we regard students as apprentice citizen-scientists, phenological education through the digital archives in CF4EE by themselves are significant in terms of the prospects for citizen science with digital archives.

Cyberforest, Phenology

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3203 **We have to learn about forest from the past.**

NAKASHIMA, T.* (1); Fukushima, K. (2)

(1) Field Sience Education and Reserch Centre, Kyoto University, Kyoto, Japan; (2) Tokyo Metropolitan University, Graduate School of Urban Environmental Sciences, Hachioji, Tokyo, Japan

Abstract: Long-term Hydrological and Ecological Research
The watersheds in mountain regions are important in the regional environment as the place in which water and much woody organic matter(litter, stems, branch, and bark)are produced and are also important for the global environment because water, woody matter, and its carbon-based components are circulated in the ecosystems of forest, river, sea and atmosphere.
We have observed a natural mixed forest at Yusen Watershed in Kyoto University Forest in Ashiu. We have carried out 4 times(every 6 years: 1992-2010)every tree census(All trees over 10 cm in D.B.H.). We also reported the transported CPOM(Coarse Particulate Organic Matter: stems, branch, bark, leaf, others and fine:1.8 －13.2kg/ha/yr) measured from about 8 hectare watershed of a mountain region in Japan from 2001 to 2010.
Forest-Environment Education
Scientists have to supply right and accurate information of forests to people. For example, the functions of forest are not almighty, because they have a hierarchy. We have to be careful to use "the devil equipments" :chain-saw and car, because they are very easy and powerful. The five elements(wood, fire, earth, metal and water) of traditional Chinese natural philosophy is the world standard in not only the Orient, but also the Occident. Wood(Tree)is just creature of those five elements. Forest is the environment of animals and other botany, this idea is also very important.

LTHER, CPOM, every tree census, five elements

KG II - HS 2121 (Uni Freiburg)

IUFRO17-580 **The development of the study course "Wood culture"**

Shalaev, V.* (1); Vladimirova, E. (1); Bardarov, N. (2)

(1) Moscow State Forest University, Mytishchy-5, Russian Federation; (2) University of Forestry - Sofia, Sofia, Germany

Abstract: This work is an attempt to combine the experience of the implementation of cultural aspect in the educational process in the specialty of woodworking technology in universities of the forestry sector - the Moscow State Forest University (Russia) and the Forest University of Forestry (Bulgaria). The surveys and questionnaires of students from different courses over several years the trend has been noticed that the young people who have chosen this specialty, perceived wood as a utilitarian material. Only a few students have a full understanding that the wood is a unique live natural renewable material. Seeing the lack of awareness of students about the possibilities of cultural wood utilization, the authors have attempted, to acquaint students with the unique opportunities of wood utilization.
It was decided to develop a course "Wood culture", which will give students the opportunity to explore the cultural aspects of wood utilization.
The designed course is a new and it is represented by 15 topics that are not studied in a main program.
The course "Wood culture" will contribute to the development of the cultural education of students, help them to choose the future profession and love it and be useful to society.

wood culture, study, course

Poster Exhibition Wednesday

183 - Forest Education

KG II - HS 2121 (Uni Freiburg)

IUFRO17-766 **Implementation status of "Children's Tree Doctor," the introductory forest environmental education program in Japan**

Sugiura, K.* (1); Shirahama, M. (1)

(1) College of Bioresource Sciences, Nihon University, Fujisawa, Kanagawa, Japan

Abstract: Children in urban areas of Japan have limited opportunities to know about forests in the course of their school education. Children do not display any interest in forests even via the games they play. A "Children's Tree Doctor" program has been implemented as part of an introductory forest environmental education program to get all children interested in forests by making them identify species of familiar trees and giving them a chance to touch and interact with them. The program is open to implementation by any organization and the method of implementation has no special rule. The purpose of this study was to assess the status of "Children's Tree Doctor" program and analyze possible future forest environmental education in Japan. Research methods involved sending a questionnaire, with contents specific to implementation, to organizations implementing the program. The results revealed that a majority of the activities targeted elementary school students and were conducted from June to October. The program helped students identify and describe almost 11 to 29 types of trees with implementation time ranging from 90 to 120 minutes. Most organizations did not collect a participation fee, but struggled to gather participants.

Children's Tree Doctor, Japan, tree species name

KG II - HS 2121 (Uni Freiburg)

IUFRO17-947 **Enhancing youth's capacity towards a more sustainable forestry community**

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(1) Johann Heinrich von Thünen Institute , Institute of International Forestry and Forest Economics, Hamburg, Germany; (2) Institute of Renewable Natural Resources, College of Forestry and Natural Resources, Los Banos, Laguna, Philippines; (3) College of Human Ecology Research & Extension Center, College of Human Ecology, Los Banos, Laguna, Philippines

Abstract: The youth has always been regarded as the source of hope for the future generation and true enough as young people we will be next in line when it comes to making decisions affecting the use or conservation of our remaining natural resources, particularly in the forestry sector. In this context and considering the multifaceted nature of forestry as a science and discipline, we have initiated a platform that aims to provide capacity-building sessions for forestry and agricultural students in the Philippines to enhance their leadership and critical thinking skills in order to prepare them for the tasks ahead of them outside the university. Through this capacity-building platform, we reach out to state universities (e.g. University of the Philippines, Southern Luzon State University) and regional forestry events (FAO's APFW 2016) in the Philippines and provide sessions to students and young professionals to enhance their decision-making skills and understanding about the interconnectedness of forestry and other sectors in society and where they can possibly make an impact. Participants of the sessions provided positive feedbacks regarding the facilitation style and relevance of topics having learned from fellow youth. The capacity-building sessions were designed to complement the technical knowledge learned through formal education.

Youth,Capacity-building,Forestry Education

Poster Exhibition Wednesday

190 - Climate change and forest health: insights from the IUFRO Task Force

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3756 **Development of a DBH-Growth Model Based on Site and Climatic Conditions**

Piao, D.* (1); Kim, M. (1); Choi, G.-M. (2); Moon, J. (1); Lee, W.-K. (1); Jeon, S.-W. (1); Son, Y. (1)

(1) College of Life Science, Seoul, Korea, Republic of (South Korea); (2) Korea Forest Inventory Center, Seoul, Korea, Republic of (South Korea)

Abstract: We developed a dynamic diameter growth model in South Korea based on stand-level diameter growth of primary tree species in 5th National Forest Inventory (NFI) data and meteorological factors. We analyzed growth factors and diameter at breast height (DBH) using three functions. The R2 for the optimal DBH-growth function by species was 0.735 to 0.789. We constructed residuals of DBH and determined the correlation between residuals and meteorological factors. Coniferous tree DBH (P. densiflora, Larix kaempferi, and P. koraiensis) was negatively correlated and broadleaf DBH (Q. variabilis and Q. mongolica) positively correlated with temperature. P. densiflora and broadleaf trees were positively correlated, although other coniferous trees (L. kaempferi and P. koraiensis) were negatively correlated with precipitation. Probability levels for precipitation were higher than for temperature. After re-analysis of data with temperature rather than precipitation, we derived a final DBH-growth model by tree species. To compare relationships between diameter growth of tree species and meteorological factors. Residual differences for coniferous trees increased (primarily L. kaempferi), whereas broadleaf trees changed little in DBH with rising temperature. Thus, coniferous species were more vulnerable to climate change than broadleaf species, which will be reflected in forest composition in South Korea.

DBH-Growth Model, Semivariogram, Residuals

KG II - HS 2121 (Uni Freiburg)

IUFRO17-410 **Lead uptake increases drought tolerance of wild type and transgenic poplar (Populus tremula x P. alba) overexpressing gsh 1**

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(1) Chair of Tree Physiology,Univeristy of Freiburg , Freiburg, Germany; (2) Chair of Soil Ecology,University of Freiburg, Freiburg, Germany; (3) Chair for Landscape Horticulture,University of Belgrade, Belgrade, Serbia; (4) Chair for Landscape Horticulture, University of Belgrade, Belgrade, Serbia; (5) Chair of Tree Physiology,Freiburg, Freiburg, Germany

Abstract: The present study was aimed to elucidate if transgenic poplars (*Populus tremula x P. alba*) with enhanced glutathione content possess enhanced tolerance to drought and lead (Pb) exposure and if they are good candidates for phytoremediation of Pb contaminated soils. Aboveground biomass accumulation was reduced upon Pb treatment in wild type but not in transgenic poplars. Lead counteracted drought mediated reduction in water content upon combined exposure; it decreased while drought increased glutathione content in leaves of both plant types. Highest Pb accumulation was observed in roots of transgenic poplars. Water deprivation enhanced Pb accumulation in roots of both plant types. Nevertheless, after re-watering Pb was subject to leakage out of the roots. Thus, transgenic poplars showed better adaptation to these stresses, single and in combination, due to improved glutathione synthesis. However, it cannot be considered a good candidate for phytoremediation of Pb, due to its small translocation to the shoots and its leakage out of the roots upon rewatering.

Pb; drought; glutathione; phytoremediation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3627 **Environmental predisposition factors to acute oak decline in England and Wales**

Brown, N. (1); Broadmeadow, S. (2); Parnell, S. (3); Denman, S. (2); Vanguelova, E.* (2)

(1) Rothamsted Research, Harpenden, United Kingdom; (2) Forest Research, Farnham, United Kingdom; (3) University of Salford, Manchester , United Kingdom

Abstract: Oak decline has been present in Europe's forests for hundreds of years, involving multiple biotic and abiotic factors acting together as a complex disease. In the UK a novel form Acute Oak Decline (AOD), has caused much concern due to its distinctive symptoms of stem "bleeding" and its potential to impact native oak species that form the largest component of native broadleaf woodland. The external AOD symptoms are found in conjunction with bacterial lesions in the phloem and galleries of the bupresid beetle Agrilus biguttatus.

During 2013 and 2014 extensive surveys were undertaken, which systematically visited oak woodlands across England and Wales to document the extent of AOD. The resulting dataset comprised over 500 locations which have been used to produce AOD risk maps. Here we present spatial analyses that investigate associations with various environmental factors and assess the extent to which AOD is linked to predisposition factors. GIS mapping was used with a logistic GAM model that accounted for spatial bias.

The results suggest a significant influence of rainfall, air temperature, elevation, nitrogen, and atmospheric deposition which play important roles, along with soil type and water runoff. These findings reemphasise the importance of predisposition factors in the Oak decline syndrome.

Acute Oak Decline climate deposition soils

Poster Exhibition Wednesday

190 - Climate change and forest health: insights from the IUFRO Task Force

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3441 **Ozone sensitivity of urban tree species based on foliar visible injury and physiological characteristics**

Xu, S.* (1); He, X. (1); Chen, W. (1); Huang, Y. (1)

(1) Institute of Applied Ecology, CAS, Shenyang, China

Abstract: An experiment was conducted to study the foliar visible injury, tissue structure and physiological characteristics of tree species (2-year-old seedlings) in Shenyang urban forest exposed to elevated O3 concentrations (120 ppb and 160 ppb) by using open top chambers (OTCs). The results showed that (1) Significant visible injuries were observed under elevated O3 concentrations. The injury symptoms of different tree species are dissimilar. Most of leaves appeared brown or pale yellow spots and patches. Robinia pseudoacacia appeared to be most sensitive to ozone among urban tree species. The coniferous trees were no obvious symptoms during the experiment. (2) Take the case of Betula platyphylla and Ginkgo biloba, elevated ozone destroyed the structure of the palisade and spongy tissue and changed the ratio of them. (3) Elevated ozone inhibited the growth for most of urban tree species. (4) Elevated ozone (160 ppb) caused the decrease in the chlorophyll and carotenoid contents of trees. (5) The electrolyte leakage (EL) and MDA content of urban trees under elevated O3 increased, indicating the occurrence of oxidative stress. (6) After 20 days of O3 treatment (160ppb), abscisic acid (ABA) content increased significantly in urban tree leaves treated with elevated O3 ($P<0.05$). While the contents of ABA in deciduous trees (G.biloba and Pinus. alba × P. berolinensi) were increased by more than 200% in comparison with treatment without elevated O3, the increasing rate of ABA content in Pinus armandii was minimum (29%) among the coniferous trees species (P. tabulaeformis, P. sylvestris mongolica, and P. armandii). Our results indicated that elevated O3 promoted senescence of trees, and the deciduous species was more sensitive to elevated O3 environment than coniferous species.

Urban tree, foliar visible injury, O3-tolerantance

Poster Exhibition Wednesday

108 - Resilience of planted forests under global change : learning from the past preparing next generation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1417 **Stability and productive ability of Douglas fir provenances in continental part of Croatia**

Peric, S.* (1); Tijardovic, M. (1); Dubravac, T. (1); Gavranovic, A. (1)

(1) Croatian Forest Research Institute, Jastrebarsko, Croatia

Abstract: Aim of the paper is to present stability of Douglas fir provenances in continental part of Croatia. Its durable, disease-resistant wood, rapid growth make it ideally suited for rapid reforestation and flexible forest management options. The aim of the research is to explore the success of different provenances in continental part of the country and to give the recommendations for forest establishment activities. Productivity of Douglas fir was evaluated on the basis of height and diameter growth. Volume production is analysed for 41st and 46th year after trial establishment. Research on basic structural parameters (DBH, total height, volume) was conducted on "Slatki Potok" locality. In each repetition, 25 seedlings (5x5) were planted, i.e. a total of 100 seedlings per provenance. Acquired data were statistically analysed with STATISTICA software. The most productive provenances originate from the lower altitudes of the Washington, Hvidilde (Denmark) and Shipka (Bulgaria). Provenance Castle Rock shows extremely low wood volume, which is result of its low survival, while the poorest wood volume shows provenance Shady Cove from Oregon. As results point to good success in comparison to forest cultures in the area of its natural distribution, there is a need of further research in Croatia.

Silvicultural parameters, wood volume, success.

Poster Exhibition Wednesday

Tropical wetlands for climate change adaptation and mitigation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2078 **Soil methane emission in ombrotrophic and minerotrophic peatland complexes in the Pastaza-Marañon Basin of the Peruvian Amazon.**

del Aguila-Pasquel, J.* (1); Lilleskov, E. (2); Chimner, R. (3); Hribljan, J. (2)

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Abstract: The largest peatland complex in South America (~35 600 km^2) was recently mapped in the Pastaza-Marañon basin (PMB) of NE Peru. Three main vegetation types were identified: (i) palm swamp forest dominated by Mauritia flexuosa, (ii) pole forest, and (iii) open sedge-dominated peatlands. Little is known about the landscape-scale variation in methane (CH_4) emission from these peatlands. Therefore, we set up 2-km transects in two peatland complexes (minerotrophic and ombrotrophic) over vegetation/water table gradients. We quantified temporal and spatial variation of soil CH_4 emissions in PMB and assessed its relationship with hydrologic/nutrient status, vegetation type, microtopography, water table position, pH, number of pneumatophores, and temperature. Methane measurements were taken using chamber-based techniques. We found that CH_4 emission rates were greater in the ombrotrophic site (155 vs. 130 mg m^{-2} day^{-1}) and in the lawn microtopographic position. Within the minerotrophic site, the open peatland had a higher emission rate (204 mg m^{-2} day^{-1}) compared to forested areas (106 mg m^{-2} day^{-1}). Rates of CH_4 are equivalent to northern peatlands on a growing season daily basis, but greater on an annual basis because of the longer growing season. Current area of open peatland is low in the PMB (3 600 km^2), however anthropogenic conversion from forested to open peatlands could lead to an increase in CH_4 emissions.

methane, Amazon, ombrotrophic, minerotrophic

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2737 **Assessing soil genesis and carbon stocks in a peat in Central Kalimantan, Indonesia**

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Abstract: Tropical peat lands provide major ecosystem services (e.g. carbon sink, water storage, biodiversity), which are important to sustain environmental balance and human well-being. In Southeast Asia large areas of tropical peat lands have been degraded due to land use changes. Particularly in Indonesia which contains 83 % of SE Asia's peatlands by area, half of which have been cleared of their native forest and drained using systems of canals in support of agri-industrial developments. Drainage of peat lands induces oxic conditions and thus accelerates carbon mineralization, carbon dioxide emissions, and causes substantial modifications of chemical and physical soil properties. Hence, pedogenetic processes result in the formation of typical soil horizons with distinctive soil properties, which are the basis for soil classification. Worldwide, the Polish and German soil classifications are the only ones which consider pedogenesis of peat soils. Thus this study investigates on a land use gradient from mixed peat swamp forest to shrub-fern land in Central Kalimantan peat soil properties, degree of degradation, and carbon stocks in different ecological settings. First results clearly reveal peat soil degradation as indicated by formation of pedogenetic soil horizons. This knowledge will be further assessed to evaluate impact on soil moisture regime affecting formation of greenhouse gas due to peat fires and rewetting activities.

Peat, Pedogenesis, Carbon stocks, Katingan project

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2356 **Anthropogenic and climate driven changes in soil CO₂ efflux from an Indonesian peatland**

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Abstract: The amount of land used to grow oil palm is rising steeply worldwide, more and more at the expense of tropical forest and peat swamps. This is particularly true in Indonesia, the world's leading producer of palm oil. The environmental costs are potentially high but uncertain. To accurately quantify tropical peatlands' contribution to global emissions and to understand how peat emissions may change in the future, long-term measurements over months, seasons, and years are needed. We collected monthly measurements of soil CO_2 efflux and environmental variables from forest and smallholder oil palm plantations on peat in Central Kalimantan, Indonesia during Jan 2014 - Sep 2015. Our study period covered wet - dry transitions during one year with relatively normal precipitation and one ENSO year. Water table level was important for explaining total soil respiration in the two land uses over the study period, but it did not tell the whole story. During ENSO, total soil respiration from forests was higher, albeit for a short time, than oil palm. This was true despite overall lower water table level in oil palm plots during ENSO, highlighting the potential importance of peat substrate quality in determining rates of CO_2 production from peat decomposition.

climate change, peat, land use, soil carbon

Poster Exhibition Wednesday

94 - Ecologically-based silviculture

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3521 **Growth of araucaria under different levels of light in agroforestry systems**

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Abstract: Araucaria angustifolia is a brazilian tree species threatened with extinction. Due it is a long-lived pioneer, it is necessary to verify the adequate levels of luminosity to increase the growth of the species in intercropping plantations. The objective of this work was to verify the growth of Araucaria under different levels of luminosity in agroforestry systems. The trial was composed by 124 araucaria seedlings of two sizes, height from 35 to 45 cm (large) and from 15 to 25 cm (small). These were planted in two conditions of luminosity: full sun (close to agroforestry) and shade (under canopy of tree species). The seedlings were evaluated 18 and 25 months after planting. At age 23 months, the agroforestry system was pruning and thinning to open the canopy. The mean increase in height was 131, 83, 24 and 18 cm and 27, 25, 15 and 13 cm in the first and second evaluation, respectively. The survival at age 25 months was 80%, 58%, 61% and 58% for large x full sun, small x full sun, large x shade and small x shade, respectively. The photosynthetically active radiation on the seedlings was 713.8 and 672.1 micromol m-2 s-1 in full sun and 8.75 and 34.0 micromol m-2 s-1 in shade before and after management. Summary, araucaria growth is strongly affected under low radiation. Furthermore, planting in consortium should be carried out with seedlings of large height size, and the agroforest system should be managed to open the canopy and to maintain the high level of luminosity on the seedlings.

Araucaria angustifolia; Shading; Agroforestry.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1464 **Growth models for natural regeneration of Sitka spruce and other conifer species under continuous cover forest**

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Abstract: The Continuous Cover Forestry (CCF) approach is becoming increasingly important worldwide, shifting the focus from clear-cutting and artificial plantation to the use of natural regeneration established under canopy cover. This will likely produce more uneven-aged and mixed species stands. However, there are few models simulating the growth of regenerating trees in such situations, and none for the United Kingdom (UK).
Sitka spruce is an important commercial species both in its native North-American range and in Europe, and the main one in the UK. It reproduces abundantly across all the country, with proven potential for CCF. Douglas fir and Western hemlock are common companions of Sitka spruce in its native range and potentially in the British mixed-species forests.
This research investigated early height and diameter growth models as function of light availability for regeneration of Sitka spruce, Douglas fir and Western hemlock growing under canopy cover. Trees regenerating under different overstorey species and canopy densities were assessed across all the UK. Canopy openness and site factors estimated with hemispherical photography were used as indices of light availability. Different model structures were calibrated and their validation results compared.
The best models for each species were presented, comparing the growth of the different species and the height versus radial increment patterns. Results shown that such growth models based on light availability can be used for uneven-aged, mixed species forests.

Sitka spruce; height growth; radial growth; CCF

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2435 **Light availability, growth patterns and species composition in uneven-aged broadleaved temperate forests**

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Abstract: As a consequence of the promotion of close-to-nature silviculture, uneven-aged silviculture is becoming more and more popular since some decades. In many cases, single-tree selection systems are applied in even-aged stands to transform them into uneven-aged stands. However, the understanding of growth processes in temperate broadleaved forests under such management regimes is still rather limited, and the implications for the sustainable provision of forest ecosystem services remain unclear.
A continuous forest cover creates a low-light environment in the understory, favouring shade-tolerant species at the expense of light-demanding species. Thus, light availability is crucial for maintaining tree species diversity. Moreover, growth rates in the understory determine intra- and interspecific competition and therefore tree species composition as well as future possibilities of wood supply.
Using multiple case studies in low-elevation deciduous forests of Switzerland, we assess light availability in vertically structured canopies and relate it to growth and species composition within the regeneration. We focus on diameter and height increment of European beech (Fagus sylvatica) and sycamore maple (Acer pseudoplatanus) at varying gap sizes. Analysing light availability and growth patterns in gaps of different size and varying stand densities will provide new insights on the competitive ability of the two species and will lead to a better understanding of suitable gap sizes and stocking volumes in uneven-aged stands.

Uneven-aged silviculture; light; beech; maple

Poster Exhibition Wednesday

94 - Ecologically-based silviculture

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2664 **Growth patterns of Quillaja saponaria sprouts after 15 years clearing in a sustainable silvicultural coppice system in central Chile**

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Abstract: Instead of the unsustainable traditional use of *Quillaja saponaria* bark of the sclerophyll forests in central Chile, a silvicultural coppice system for industrial production of saponin has been proposed. It consists of an improvement cutting with clearing, thinning and pruning of sprouts. However, knowledge of the response to interventions is the basis for coppice management guidelines. Therefore the aim of this study was to analyze the growth patterns of quillay sprouts after 15 years of a clearing in a coppice system. For the study six stools with their respective sprouts (n= 24) of an unmanaged and cleared stand (in 2001) were selected. In each sprout, basal diameter, basal area, height, dominance and biomass was determined. Also a wood core sample was extracted and current annual diameter growth was calculated. According to its dominance, unmanaged sprouts had an average annual diameter growth between 0,11 and 0,42 cm/year. By contrast, those cleared reached a growth between 0,87 and 0,92 cm/year. Growth patterns are influenced by the number, basal area of the sprouts in the stool and the diameters, perimeter and heights of the stools. New coppice management guidelines, based on knowledge of the dynamics of growth of *Quillaja* sprouts were established.

sprouts, diameter, biomass, growth, Chile

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3011 **Effects of pre-commercial thinning on growth and stem form of naturally regenerated European beech (Fagus sylvatica)**

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Abstract: Due to stem densities and high costs of manual labour, early thinning in naturally regenerated stands of European beech (Fagus sylvatica) does not generate any profit normally. Early stand interventions should consequently be justified by larger growth rates and improved stem quality, leading to higher revenues later in the rotation. Based on a two statistically designed field experiments established in young stands of beech in Denmark, we investigated the influence of pre-commercial thinning on individual tree growth and stem quality. Thinning practices included no, strip-wise, selective and chessboard thinning with stem densities ranging from more than 10^5 down to 200 ha^-1. Tree and stand characteristics were measured at regular intervals during 18 years. Treatment effects were evaluated primarily for one preselected potential future tree for every 100 m^2. Potential future crop trees were selected based on regularity of spatial distribution and objective criteria of growth potential and stem quality. Results indicate that stem diameter growth was significantly higher in chess-board thinning while potential future crop trees in all other treatments had more similar growth. However, pruning was necessary in chessboard thinning in order to produce premium quality timber. In summary, pre-commercial thinning of young beech generally does not lead to significantly increased growth rates and better stem quality of potential future crop trees when considering only 100 trees ha^-1. The results are important for the ongoing transition to close-to-nature forestry across Europe because increasingly irregular forests will introduce interior stand edges, which will likely have similar effects on the wood quality as observed in this study.

Natural regeneration, thinning, stem form, growth

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3340 **Regional early growth performances of Larix kaempferi trees planted in harvested Larix kaemferi plantations, South Korea**

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(1) Forest Practice Research Center, National Institute of Forest Science, Pocheon- si, Korea, Republic of (South Korea)

Abstract: This study was conducted to compare the regional early growth performances of Larix kaempferi trees planted in harvested L. kaempferi plantations, South Korea. Two-year-old bare-root seedlings of L. kaempferi were planted in four sites (Yeongju, Gimcheon, Chuncheon, and Inje). All sites were established with three plots (400m2/plot) in 2010. Five soil samples per plot were collected to the depth of 20 cm in October 2010, 2013, and 2016. We analyzed soil physical and chemical properties such as total nitrogen, available phosphorus, and organic matter. We measured root collar diameter (RCD) and height (Ht) of trees (30 trees per plot) in October from 2010 to 2016, and then calculated stem volume. Annual mean RCD, Ht, and stem volume of 5- to 9-year-old in the Chuncheon site were significantly higher than those in the other sites. It is related to the fact that total nitrogen, available phosphorus, and organic matter concentrations in the Chuncheon site were relatively higher than those in the other sites. Therefore, plantation sites of L. kaempferi should be selected in consideration of soil nutrients for better growth based on the current study.

growth, larch, reforestation, soil properties

Poster Exhibition Wednesday

94 - Ecologically-based silviculture

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3343 **Study for natural regeneration mechanism of Pinus densiflora in South Korea**

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Abstract: This study was carried out in order to understand the natural regeneration of P. densiflora in south korea. We created an experimental site applied mother tree method, strip and group clear cutting in 2012. We analyzed seed inflow amount on forest floor, survival rate of seedling by age, amount of seedling and actual cost for 4years. Seed inflow amount was different every year depending on fruiting cycle(920-thousand seed/ha in good year, 440-thousand seed/ha in bad year). Occurrence amount of 1 year old seedlings were 22-thousand seedling/ha(occurrence rate 2.3%). Survival rate of seedlings were 61% for 1 year old seedlings, 84% for 2 years old seedlings and 95% for over 3 years old seedlings. After 4 years of regeneration, the number of seedlings were 6,071 seedling/ha for over 2 years old(31.9%), 3,690seedling/ha for over 3 years old (19.4%) among total 19,048 seedling/ha in experimental site. Actual cost was 4,851-thousand won/ha(4,410usd/ha) to create experimental site and to mow the lower story vegetation for 4 years. This figure is nearly 30% lower than artificial regeneration. This result is expected to use as the basic information to develop practical technique for natural regeneration of P. densiflora.

mother tree, natural regeneration, red pine

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3136 **Estimation of cones and seed amount of Larix kaempferi age clas V in South Korea**

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(1) National Institute of Forest Science, Forest Pratice Research Center, Poschen-si, Korea, Republic of (South Korea)

Abstract: This study was carried out in order to predict of seed supply on regeneration area through accurately understanding of seed quantity for natural regeneration of L. kaempferi. We surveyed branch's size and position, amount of cones per branch, amount of scales and real seeds per cone after cutted 3 trees that there are superior in cone quantity. The mean number of branches was 62, mean diameter and length were 4.1cm and 3.3m respectively. The total number of cones were 7,423 per tree. The mean length and width of cones were 27.9mm and 15.6mm respectively. The mean number of fall off cones from branches when trees cut was 31% of total cones. Also, ratio of cones by divided three even part of branch's position was lower 5.3%, middle 64.4% and upper 30.3%. The mean number of scales was 58 per cone. In accordance with this result, seed amount was estimated 116 per cone. However, real number of seed amount was 93 per cone therefore it was 80% of estimation. Based on this results, the total number of seed amount was estimated 690,300 per tree. This result is expected to use as the basic information for natural regeneration of L. kaempferi.

cone, scale, Larix kaempferi, natural regeneration

Poster Exhibition Wednesday

Research Advances for the Meliaceae

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1112 **Conservation of genetic resources of Azadirachta Indica a. Juss. (neem) - an Indian experience**

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Abstract: Selection of appropriate species and provenances can mean the difference between success and failure in forestry programmes, and also has important implications for biological conservation. The neem tree, Azadirachta indica, belonging to the family Meliaceae, is an evergreen multipurpose tree native to the Indian subcontinent and Southeast Asia. With an aim to assess the extent and nature of variability of neem in South India, twenty four populations comprising about 400 accessions were identified in different agro-climatic zones of South India. Seed biology of neem encompassing fixing the optimum time for seed collection and standardizing collection methods; delineating storage temperature and moisture conditions to maintain the viability of seeds, major biochemical changes associated with seed deterioration and outlining the genetic variation within and between populations were worked out. Variation in fruits and seed parameters such as seed weight, seed size, germination percent and oil content were studied for establishing correlation between oil content and seed and fruit characters within populations. All the seed samples were accessioned by National bureau of Plant Genetic Resources (NBPGR) for long term conservation.

Global programmes for the evaluation and improvement of neem were taken up with concerted efforts of the International Neem Network (INN) to improve the genetic quality and adaptability of neem and to improve its utilisation. Under the INN, an International provenance trial of neem comprising 18 provenances from 6 countries is being maintained. Seed exchange programmes were also part of the network activities between the participation countries. Three Tanzanian provenances are being evaluated under Indian conditions, periodical growth data collected and analyzed. The survival percentage after three years was the highest in the Tanzanian provenances (97.0%) suggesting its adaptability to Indian conditions.

Poster Exhibition Wednesday

105 - Sustainable co-production of wood and non-wood forest products

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3102 **The Hidden Potential of Agroforestry Systems in the Chapare Coca production Area, Bolivia**

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Abstract: During the neoliberal period was characterized by policies such as the thin industry shutdown, privatization of public services and the zero coca program. This program introduced the monoculture of banana and did not succeed in reducing coca production. In this study, I will show that forestry agroecosystems (FA) are much more profitable than coca in terms of economically-sound ventures.The principal objective was to show that FA offer an economically sound choice to Bolivian producers in Coca production areas.
Approach and methods: AgroProductive Diagnostic Approach (APDA)
The APDA objective is to study the aspects of the agronomic situation of a region and its transformation in order to identify ecological, economic and social issues at the analysis. This analysis is useful for the development of public policies. It emphasizes interactions between systems. A total of 16 interviews were conducted.
Results
The first,the AF at Valle del Sacta (secondary forest, buffaloes and caprines, fruits,grazing species). The second, the coca system.
This study was made at the Valle del Sacta University Unit located at 244 km from Santa Cruz. .

The coca system presented a low value for natural capital due to the monocrop nature. The economic capital value is also low due to the usechemicals for pests. On the other hand, the human, physical, and social capitals values are higher due the organization of coca growers.
CONCLUSIONS
The Agroforestal Systems permitted to increase the producer' income at least 20% in contrast to the coca crop itself.
According to the analysis of the collected data, the cost-benefit analysis for the Agroforestal System is at least 20% higher than the coca crop
We refute the Davalos et al (2008) findings stating that the farm income of a coca growing farmer is about 54% higher than the income of a non coca producing farmer which is not possible in comparison with our study.

agroforestry systems, coca, cattle, tropical fruit

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2495 **Questionnaire survey on local use of edible wild plants/mushrooms after the Fukushima Daiichi Nuclear Power Plant accident**

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Abstract: Radioactive contamination due to the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident had reduced a wide range of forest ecosystem services (provisioning and cultural services) in eastern Japan. The effect, in particular, drastically affected the use of non-timber forest products (NTFPs) and forest recreation. However, assessing the changes in these activities is rather difficult in rural areas since harvesting is primarily conducted individually by local residents, which generally has not been well recorded in governmental statistics. For elucidating these changes, e.g., harvesting edible wild plants/mushrooms after the accident, we conducted questionnaire surveys of each household in settlements in both the western and eastern Fukushima Prefecture with different air radiation dose levels. Questionnaire items included changes in monthly frequency of harvest, use after harvest (i.e., self-consumption, gift, or sale), and gift destination before and after the accident. We also asked the reasons why they harvested NTFPs before the accident and why they reduced the frequency of harvest after the accident. We found a sharp decline in these activities and related social capital (e.g., gift-giving relationship), particularly in the settlements nearer to FDNPP. The accident had accelerated the decline in harvesting activities, with a decreasing trend in the aging society.

questionnaire survey, NTFP, Fukushima

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2498 **Pine nuts and timber, sustainably yielded from Mediterranean pine woodlands?**

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(1) INIA-CIFOR, iuFOR UVa-INIA, Madrid, Spain; (2) Junta de Castilla y Leon, ST MA Valladolid, Valladolid, Spain; (3) Forest Science Centre of Catalonia (CTFC) , Sustainable Forest Management Unit, Solsona, Spain; (4) U. Lisboa, Instituto Superior de Agronomia, Lisboa, Portugal

Abstract: Since Antiquity, stone pine has been an important forest tree in Mediterranean countries, providing timber, firewood and cones, whose edible Mediterranean pine nut kernels are a gourmet nut moving several hundred million euros annually. Its woodlands are also highly relevant by their environmental, ecological and cultural value.
Cones harvesting or its licenses had been giving higher revenues to forest owners than slow-growing, low-value timber. Nevertheless, in most Mediterranean countries, ongoing climate change and increased cone pests' prevalence have reduced the amount of cones harvested in the last few years. Industries have reported also a drop in kernel per cone yield obtained in factory, especially since the accidental introduction of the invasive alien seed pest Leptoglossus occidentalis. As a consequence, income for forest owners, cone pickers and processors has plumped, and economical sustainability of the forest system and value chain is seriously jeopardised.
Forest owners are intensifying cone production up new, open-grown plantations on forest or farmland, grafted or not. In Portugal and Turkey, stone pine area has increased fourfold in few decades, often focussing on optimised cone production, rather than on multipurpose forestry. The lack of an effective integrated pest control for the Leptoglossus bug and incertitude of climate scenarios call into question the feasibility of traditional pine forest management, sustained only by diminishing revenues from timber and cones in absence of payments for essential ecosystem services.

Pinus pinea, wild forest food, domestication

Poster Exhibition Wednesday

105 - Sustainable co-production of wood and non-wood forest products

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2541 **Potentials of the Brazilian Bamboo: A study about its evolution in Brazil.**

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(1) Instituto Federal de Brasilia, Brasilia, Brazil; (2) Universidade de Brasilia, Brasilia, Brazil

Abstract: The Bamboo repercussions is due, especially by the environmental and socioeconomic appeal. Thus, this study aims to verify the evolution of the Bamboo in Brazil. Analyzing public and private data, we observed more than 180 endemic species cataloged. The genus Guadua sp. covers 4.5 million hectares in the State of Acre, almost 80% of China's native bamboo forest production. Bambusa, Dendrocalamus and Phyllostachys genera predominate the South and Southeastern Brazilian region. Between 2011 and 2016, important changes have occurred as the creation of the National Policy for Incentives for Sustainable Management and Bamboo Farming, Brazil's Government approval for inclusion in the International Bamboo and Rattan Network (INBAR) and the State Development Plan of the Bamboo Productive Chain in Acre. Besides there has been an increase in the number of private and public enterprises and financing lines directed to this Brazilian sector. The price range of a treated stick is between R$10.0 to 100.0 per linear meter, depending on the species, diameter and use. Even with the Brazilian political and economic crisis, some ventures have shown returns of profitability higher than 35%. The Brazilian market is still incipient, since supply still does not meet demand satisfactorily, but Brazilian potential has been modestly exploited, with a promising future.

Bamboo, Brazil, Political and Economic, Potential.

KG II - HS 2121 (Uni Freiburg)

IUFRO17-365 **Visual perception of adherence of different wood finish products**

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Abstract: The major functions of wood finishes are to protect the surface, improve the appearance and facilitate cleaning. The most common treatment is applying finishing products to the wood surface. This, closes the pores and prevents or minimizes the contact with air and moisture present in the environment. Wood finishes are influenced by the surface characteristics of the material, the type of product employed, environmental conditions and by application techniques. The main objective of this study was to visually evaluate the adherence of three different types of wood finishes on MDF and plywood. Lacquer paints with and without a primer, varnish and sealant were tested. Finishes were applied with a 1" brush and paint roller, while for the lacquer paint a pneumatic spray gun was used. The coat test of adhesion of each type of finish was per NBR 14535 (2000), a Brazilian Standard. The finished films were evaluated by 25 evaluators, including designers, technicians in furniture manufacturing, professionals at furniture production areas and furniture users. The MDF panels with lacquer finishing with and without primer were more highly rated, while for plywood only the coating with black lacquer with primer application presented satisfactory results. This is due the fact of plywood panels use wood veneers in theirs outer layers, providing the wood profile, with figures and features cracks in the material, differently from MDF panels which have homogeneous surface due to the use of wood fibers in theirs manufacturing process. Thus, it was concluded that for a better surface finish the application of primer assists in the finished film adhesion and improves the perception of the surface quality.

visual evaluation, varnish, sealant, furniture

Poster Exhibition Wednesday

2 - Co-existence of human and wildlife in changing landscapes and climate

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3823 **An evaluation of conservation effort based on elephant crop raid distribution in Bia Conservation Area, Ghana**

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Abstract: Wildlife managers often wish to evaluate the effectiveness of conservation effort by measuring trends in wildlife populations. In western Ghana, the Bia Conservation Area (BCA) forms a significant portion of forest elephant range. Elephant crop raiding distribution dynamics in BCA were analysed as a means of evaluating the success or failure of conservation effort in the area. We monitored trends in distribution of elephant crop raiding activities before (2004) and after (2009) the 5-year Protected Area Development Program (PADP) Phase II. PADP II was designed to build capacities of patrol guards, control illegal activities within the park and support conservation education programs. Results indicated that mean elephant range increased greatly from 45% coverage of the park in 2004 to 78% in 2009, resulting in a wider distribution of crop raiding activity, previously confined to the south eastern section and now expanded to the northern limits of the park. We operated under the implicit assumption that increased law enforcement and conservation effort in BCA, will lead to better conditions for elephants and therefore wider distribution of elephants and their crop raiding activity. The increase in distribution of crop raids by elephants calls for more effort to include conservation strategies that reduces human wildlife conflict in the management priorities of BCA. Conservation measures that allow for the peaceful co-existence between local communities and elephants and have the potential to link conservation to the socio-economic development of the fringe communities are recommended.

Conservation, elephants, human-wildlife conflict

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3056 **Determination of the land use conflicts in the gavidia watershed of the National Park Sierra Nevada, Merida, Venezuela**

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Abstract: The watershed Gavidia is located within the boundaries of the National Park Sierra Nevada, for this reason is governed by the Management Plan and Regulation of Use of the Park (PORU). However, at present, due to the constant changes of use of the Earth is disrespecting the zoning established in the watershed, bringing normative use conflicts in the area of study, where the socio-economic needs of the population are faced and the interests of the organisms in charge of the protection of the natural areas. The objective of the investigation is to determine land use conflicts in the watershed Gavidia of the National Park Sierra Nevada, through the analysis of the conceptual, technical, legal and cartographic aspects that underpin the Areas Under Special Administration Regime and the identification of the current use of the land in the watershed, in order to be able to determine the real conflicts existing in that area, using the Geographic Information Systems, resulting in the current Land Use map being the basis for obtaining the Use conflict map in the watershed Gavidia.

Gavidia, Conflicts, Use.

Poster Exhibition Wednesday

92 - Concepts and assessments of forest ecosystem services and benefits

KG II - HS 2121 (Uni Freiburg)

IUFRO17-1901 **Assessment of provisioning forest ecosystem service potential in Latvia**

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(1) Latvian State Forest Research Institute "Silava", Salaspils, Latvia

Abstract: With 54% forest cover, Latvia is the 4th most forested country in Europe, and forest sectors plays a key role in the national and rural economy. One half of all forests is state-owned. During recent years the interest in ecosystem service evaluation has grown internationally, on European and also on national level. Ecosystem services are understood as the contributions of ecosystem structure and function - in combination with other inputs - to human well-being, and ecosystem service potential is the hypothetical maximum yield of selected ecosystem services in a given area. Ecosystem service classification according to CICES was used in the study. Provisioning ecosystem service potential was assessed in two model catchments -in state-owned commercial forests in the southern part of Latvia (size 2037 ha) and in protected area (size 2461 ha). We developed indicators for each ecosystem service sub-group based on the site classification, assigned ecosystem service potential values to each compartment and created spatial maps. This evaluation will be further used to analyse the impact of forest management on forest ecosystem service provision. The study was carried out in frames of a collaboration project between the joint stock company "Latvian State Forests" and Latvian State Forest Research Institute "Silava".

forest ecosystem services (FES), FES potential

KG II - HS 2121 (Uni Freiburg)

IUFRO17-324 **Socioeconomic Impact of the Program of Payment for Environmental Services-Reforestation Modality- in Northwestern Costa Rica**

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(1) National University, Heredia, Costa Rica; (2) National University, University of Costa Rica, Heredia, Costa Rica

Abstract: The purpose of this study was to assess the socioeconomic impact of the Program of Payments for Environmental Services (PPES) on beneficiaries who engaged in reforestation contracts between 1998 and 2013 through two forest grassroots organizations (FGO) in the northwest region of Costa Rica. Besides an extensive literature review, field visits and interviews with beneficiaries and program experts helped identified socio-economic characteristics; then a set of principles, criteria and indicators was developed and used to measure the social and economic impacts. The follow-up analyses considered three different approaches: the role of FGOs, the period (1998-2000, 2005-2007 and 2011-2013) and an overall analysis. General results indicate that beneficiaries are mostly impacted on the social dimension and those who process their contracts with the more consolidated organization derive more benefits. As main conclusion, the program has strengthened local capacities for forest development in the area, mainly through the active participation of FGOs and beneficiaries, although through time the perception of such benefits seems decreasing.

Assessment grassroots organizations reforestation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3362 **Comparison of Urban Forest with peri-urban Forest Focusing on Air Purification Function**

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Abstract: The ecosystem is the essential element in maintaining the human health and the quality of life. The forest has diverse functions but receives a lot of pressure for development without being evaluated its value due to its characteristic of the public goods. In particular, as human society develops and cities expand, the development pressure of forests near the city is increasing. Therefore, to determine the value of forest precisely and to make sustainable city, the importance and the need to evaluate the diverse functions of the urban forest quantitatively are being increased.
The forest have close relationship with the climate change, carbon emission, low-carbon, etc.. In South Korea, the government manages forests by 4th Basic Forest Plan. The plan is a guideline to manage the environmental health of the forests in order to manage the various functions of the forest and increase productivity. The functions of the forest can be classified mainly into 7 functions such as the air purification function, watershed conservation function, soil erosion prevention function, forest recreation function. The purpose of this study is to evaluate the value of air purification function among various functions of urban forest using ecosystem service concept which quantitatively evaluate the benefits provided by ecosystem for the coexistence of humans and ecosystems.
To evaluate the function, the urban forest and peri-urban forest were selected and compared of their characteristics. The urban forest is defined as the forest within the city having 1 million population. We used the I-tree model, a global ecosystem service assessment tool, to evaluate the air purification functions of urban forests and peri-urban forests using Detailed actual vegetation map, biotope map and forest information provided by the government. The results of this study can be useful for the expansion and management of urban forests.

ecosystem service, air purification function

Poster Exhibition Wednesday

92 - Concepts and assessments of forest ecosystem services and benefits

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2298 **Assessing the provisioning potential of ecosystem services in a Scandinavian boreal forest: suitability and tradeoff analyses on grid-based wall-to-wall forest inventory data**

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(1) University of Eastern Finland, Joensuu, Finland

Abstract: Determining optimal forest management to provide multiple goods and services, also referred to as Ecosystem Services (ESs), requires operational-scale information on the suitability of the forest for the provisioning of various ESs. Remote sensing allows wall-to-wall assessments and provides pixel data for a flexible composition of the management units. The purpose of this study was to incorporate models of ES provisioning potential in a spatial prioritization framework and to assess the pixel-level allocation of the land use. We tessellated the forested area in a landscape of altogether 7,500 ha to 27,595 pixels of 48 ×48 m^2 and modeled the potential of each pixel to provide biodiversity, timber, carbon storage, and recreational amenities as indicators of supporting, provisioning, regulating, and cultural ESs, respectively. We analyzed spatial overlaps between the individual ESs, the potential to provide multiple ESs, and tradeoffs due to production constraints in a fraction of the landscape. The pixels considered most important for the individual ESs overlapped as much as 78% between carbon storage and timber production and up to 52.5% between the other ESs. The potential for multiple ESs could be largely explained in terms of forest structure as being emphasized to sparsely populated, spruce-dominated old forests with large average tree size. Constraining the production of the ESs in the landscape based on the priority maps, however, resulted in sub-optimal choices compared to an optimized production. Even though the land-use planning cannot be completed without involving the stakeholders' preferences, we conclude that the workflow described in this paper produced valuable information on the overlaps and tradeoffs of the ESs for the related decision support.

inventory; remote sensing; spatial MCDA; Zonation

Poster Exhibition Wednesday

68 - Forest Adaptation and Restoration under Global Change

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2317 **Effect of stand density on nutrient status and foliar mass production in a planted Pinus pinea forest (Olmedo, Spain)**

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(1) INIA, Medio Ambiente, Madrid, Spain; (2) INIA, CIFOR, Madrid, Spain

Abstract: Forest management techniques influence the nutrient cycling and nutrient status especially in those with scarce resource availability. Optimization of nutrient and health status should be taken into account to increase tree resilience against climate change.
The study site has being stablished in 2006 in a 30 ha Pinus pinaster 10 year even-aged plantation in Olmedo (Valladolid) over poor sandy good drained soils with a continental Mediterranean climate. After clearing the initial density of 1200 trees/ha was reduced to a final density of 150, 300 and 500 trees/ha respectively. The effect of the clearing intensity in the foliar mass production and nutrient status was studied twice 7 and 9 years after the initial treatment.
The clearing produced a significant increase in tree growth (diameter, height and foliar mass) proportional to the stand density that was mainly explained by an increase in foliar nitrogen and boron.

Clearing, nutrient use efficiency

Poster Exhibition Wednesday

9 - IUFRO Task Force on Biological Invasions in Forests

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2690 **Novel Calonectria species from plantation and nursery soils in South-East Asia**

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(1) Forestry and Agricultural Biotechnology Institute, University of Pretoria, Pretoria, South Africa; (2) China Eucalypt Research Centre (CERC), Chinese Academy of Forestry (CAF), ZhanJiang, China; (3) Forest Protection Research Centre, Vietnamese Academy of Forest Sciences, Hanoi, Viet Nam

Abstract: Plantation forestry is expanding rapidly in South-East Asia in order to provide to the growing demand for wood and wood products. Currently, Vietnam and Indonesia have the most extensive plantations, especially of *Acacia* spp. and *Eucalyptus* spp. in this region. As the forestry plantations expand, the threat from pests and diseases also grows. *Calonectria* species represent an important group of pathogenic fungi that are associated with various diseases of plantation and nursery tree species in tropical and subtropical regions including South-East Asia. During 2015 and 2016, extensive surveys were conducted across plantations and nurseries of Vietnam and parts of Indonesia, where a large number of isolates were retrieved from diseased leaves and soils associated with symptomatic trees. The aim of this study was to identify and resolve the phylogenetic relationships among these isolates using DNA sequence comparisons for four gene regions including Beta-tubulin, Calmodulin, Histone H3 and TEF-1alpha as well as morphological characters. From a collection of 165 isolates, 9 known species as well as approximately 10 undescribed species were obtained. The high diversity of *Calonectria* species found in this study supports the view that South-East Asia is a centre of diversity for Calonectria species and that many more species in this genus remain to be discovered. This work also represents the first phylogenetic study of *Calonectria* species from Vietnam.

Cylindrocladium, eucalypt, phylogeny, taxonomy

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3451 **Detecting three different parasitic nematodes on Acacia mangium seedlings in Vietnam**

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Abstract: Acacia is one of the most widespread fast - growing tree species planted in plantation forestry programs in Vietnam. The total forest plantation in Vietnam is 3.6 million hectares, of which acacia generally accounted for 1.3 million ha (Acacia mangium accounted for about 900.000ha). Due to their rapid growth and tolerance to very poor soils, Acacia mangium is playing an increasingly important role in order to sustain a commercial supply of wood products whilst reducing pressure on natural forest ecosystems. However, currently, the source of seedlings for acacia plantation are damaging by parasitic nematodes in the nursery. These nematodes - anonymous destroyer, caused slow root growth, yellowing leaves, especially enabling the fungus such as Phytophthora spp., Pythium spp. or Fusarium spp. enter the plant from the soil to kill the tree. Nematodes were obtained by using funnel of Bearmann. Using morphological characteristic of stylet, tail, three species of nematode were identified which were sedentary endoparasite (Meloidogynesp.); sedentary semi-endoparasites (Rotylenchulusreniformis), endoparasites migrators (Pratylenchus sp.). These were harmful nematode species which were previously found on agricultural crops. This study reports their first appearance on Acacia mangium in Vietnam.

Acacia mangium, parasitic nematodes

KG II - HS 2121 (Uni Freiburg)

IUFRO17-2519 **Pinus elliottii in riparian zones as a reduction factor in the quality of ecosystem services**

Ramos, M. (1); Magro, T.* (2)

(1) Chico Mendes Institute for Biodiversity Conservation, ICMBio, Capão Bonito-SP, Brazil; (2) Forest Science Department, University of São Paulo , Piracicaba, Brazil

Abstract: It is already known that riparian zones are extremely important as generators of ecosystem services. If these areas are located near Pinus plantations they are highly invaded by this exotic specie reducing the quality of ecosystem services provided by the riparian zone. This study compares and assesses structural characteristics of the canopy and the ground between native and pine and also the soil pH under native and pine vegetation recorded in a Brazilian protected area. According to results there is a significant density of Pinus elliottii occupying the space of native forest and non-forest vegetation. It is important to highlight that the invasion process is being continuous with recruitment of new individuals, due to the arrival of propagules. This situation can certainly lead to the continuous replacement of native vegetation by Pinus elliottii, mainly in open areas of the wetland, and in the forest area that are under effect of natural impact or death of native trees. Environmental impacts caused by the presence and pine invasion indicate its eradication and management against re-infestation.

Poster Exhibition Wednesday

93 - Silviculture for non-wood ecosystem services

KG II - HS 2121 (Uni Freiburg)

IUFRO17-750 **Structural indicators as a link between silviculture and ecosystem services**

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Abstract: Forestry has a long tradition of managing forests solely for the provision of individual ecosystem services (ESS); e.g., timber production. Although current forest policy in central Europe targets an integration of different ESS in the management activities of forest enterprises, this integration has not yet become an inherent part of regular silvicultural practices. It has not yet been possible to translate the abstract initial systems provided by initiatives such as the 'Millennium Ecosystem Assessment' or 'The Economics of Ecosystems and Biodiversity' into relevant silvicultural parameters; this is especially true for non-wood ESS. However, a review of traditional silvicultural approaches such as thinning and regeneration measures emphasises the key role that structural elements (e.g., various tree species, gaps) and their attributes (e.g., crown dimension, stem form) play in the provisioning of different ESS. We suggest that measurable forest structures, or structural indices applied on different spatial scales, can be linked successfully to all four categories of ESS: (i) provision, (ii) regulation, (iii) habitat and support, and (iv) culture and human well-being. This approach must be adapted, especially for the latter category, which involves a high level of human subjectivity.
Following an overview of existing structural information and indicators used by different scientific disciplines for the description of forest ecosystems, we show how useful these structural indicators are to describe forest characteristics relevant for the provision of different ESS. We examine the existing silvicultural knowledge base to identify appropriate means to specifically support non-wood ESS. To conclude, we identify the gaps in the current information that must be filled in order to facilitate the combination of different structural elements so as to provide a range of ESS with a defined forest area.

forest structure, indicators, ESS, recreation

KG II - HS 2121 (Uni Freiburg)

IUFRO17-3443 **Silvicultural measures to optimize both production and recreation services of the urban forest**

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(1) FGMRI, Strnady, Opocno Research Station , Opocno, Czech Republic

Abstract: Urban forests are usually affected by anthropogenic activities. The public need to be provided with recreation service of the forest; this service is then complicated to be satisfied. It is necessary to find approaches minimizing risks and favoring optimization of both production and recreation functions. To analyze need of the local people, a questionnaire survey was conducted in the urban forests of Ostrava City. We obtained 131 questionnaires being filled in properly. 92% people indicated they were frequent visitors in the area of interest. As for time, more than half people answered they preferred less than 30 minutes travel; only 15% were willing to spend more than 1 hour on the way. The most common travelling was walking and cycling which confirms a good availability of forested areas surrounding the City. When visiting the forest, people prefer leisure activities such as having a rest (70%) and doing sports (43%). Only 4% responders use urban forests as a source of fuel-wood. The locals also like mixed stands (ca 50%) with two and more tree species sharing the stands. The most appreciated trees are Norway spruce and Scots pine. Negligible number of answerers prefer monocultures. Visitors think that logging, skidding and hauling affect their needs negatively. The worst thing disturbing their recreation is waste left in the forest. The questionnaire results are to be one of documents which help us to propose particular silvicultural measures in the area of interest.

urban forests, recreation, silviculture

Theme 1: Forests for People

102 - Bringing carbon to small-scale forest owners - role of buy-in mechanisms for bridging scales and

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2611 **Carbonscapes - The effect of carbon sequestration driven woodland creation on management culture in Scotland**

Bowditch, E.* (1); Lawrence, A. (1)

(1) Inverness College UHI, Inverness, United Kingdom

Abstract: In Scotland, the UK's Woodland Carbon Code (the voluntary standard for woodland creation projects where claims are made about the carbon dioxide they sequester) has led to an increase in carbon-woodland partnerships. Two emerging issues could either undermine or aid the Code's further adoption into practice: comprehensive access to seemingly distant markets for diverse landowners; and the influence of carbon sequestration aims on woodland management. The subsequent impact on woodland management culture and the wider landscape, in a country where woodland management is lower priority than in the rest of Europe, may affect the development and utility of regional partnership aiming to encourage applied ecosystem approaches. This study uses social research with stakeholders in the supply chain of the Scottish woodland-carbon market (Forestry Commission, suppliers, consumers and bridging organisations) to inform the way in which policy underlies shifting management practices. Important issues for capacity building and connectivity between prospective subscribers, and strategic level administration, such as education, clarification of the process and management responsibilities, as well as ownership of intangible products require comprehensive development. This highlights a shift in thinking that is viewed as both progressive and a hindrance by individual owners but is vital to Scotland's working interpretation of resilient woodlands.

landowners, carbon markets, partnerships, forests

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3548 **Investment in forest carbon offset: the perspective of private forest landowners in Korea**

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(1) Department of Forest Sciences, Seoul National University, Seoul, Korea, Republic of (South Korea)

Abstract: The Forest Carbon Offset Scheme was introduced in 2013, aiming to transform forest's carbon sequestration function into forest carbon credits traded in greenhouse gas Emission Trading System (ETS) which became effective in 2015. Private forest landowners, owning 68% of the country's forests, are potentially the main suppliers of forest carbon credits. However, as of mid-2016, only seven out of the total 89 registered forest carbon offset projects (8%) have been registered by private individual forest landowners. There are convoluted barriers for private forest investment in Korea, complicating the landowners' willingness to invest in forest carbon offset projects. Thus, factors affecting private forest landowners' investment in forest carbon offset project need to be understood. 109 private forest landowners actively engaged in forest management in Geumsan-gun area were selected for a mail survey. A logistic regression model was applied to identify determinants of the landowners' probability to invest in forest carbon offset projects, resulting in an investment probability function. We hypothesize that forest area, institutional knowledge, attitude towards climate change have positive effects while landowner's age, forest age, and timber production have negative effects on private forest landowners' probability to invest in forest carbon offset project. The investment probability function derived from this study can provide the basic information for the government to formulate information strategy to promote private forest landowners' participation in the Forest Carbon Offset Scheme.

Investment, forest carbon, private landowners

K 5-7 (Konzerthaus Freiburg)

IUFRO17-741 **REDD+ finance perspective as solution to community forestry in Congo Basin**

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(1) Center for international forestry research (CIFOR), University of Maine Lemans (France), Yaoundé, Cameroons; (2) university of Dschang, CRESA-Foret bois, Yaoundé, Cameroons; (3) University of Maine lemans, Lemans, France; (4) Center for international forestry research (CIFOR), international institute of tropical agriculture (IITA), Yaoundé, Cameroons

Abstract: Community forestry has been highlighted as a situation of forest exploitation that involved local people and that benefit are used for social infrastructure (FAO, 1978). Congo basin is moving slowly into local forestry management characterized by community involvement. Decree 95/531/PM of August 23 1995 accompanying the 1994 Forestry Law established the legal requirements and steps to create a community forest. They are found in the non-permanent forest estate according to Cameroon system of forest management and accounts for 20% of the forest. The question of the impact of CF on livelihood of local community remain since studied has shown mixed results. REDD+ can be seen in this way as possibility to improve this type of management. This paper intend to analysis the result of ten years activities of a CF in south east Cameroon in compare to REDD+ opportunity for CF. based on a socioeconomic and biophysical survey in Mpemog community forest we came out with significant outputs. Results show that primary forest has a highest ecological value 4806.6 USD/ha and 1146 USD/ha for mixed crop. Taken in account these value can lead to another expectancy from community people despite that that management skills have to be enhanced.

community forest,REDD+, ecological value,

Theme 1: Forests for People

102 - Bringing carbon to small-scale forest owners - role of buy-in mechanisms for bridging scales and

K 5-7 (Konzerthaus Freiburg)

IUFRO17-578 **Measuring non-carbon benefits of bio-carbon projects and their delivery in existing projects in Southern Africa**

Chirwa, P.* (1)

(1) University of Pretoria, Forestry Programme, Pretoria, South Africa

Abstract: The Southern African Development Community (SADC) region has seen a proliferation of bio-carbon projects in the past decade in a drive to address the climate change agenda through projects ranging from REDD+, reforestation and afforestation activities, sustainable forest management to climate smart agriculture and bioenergy (biofuels) production This study examined the smallholder farmer non-carbon benefits accrued from existing bio-carbon projects and the barriers and enhancers that have affected these projects. The development of bio-carbon projects in Africa is constrained by barriers including complex rules set by buyers, high costs and poor governance. Another challenge to attracting more tree-based carbon sequestration projects in southern Africa and indeed Africa is the shortage of organizational capacity to manage carbon projects and establish links to international buyers. In addition, securing property rights and land tenure and improving governance is of great importance in the establishment of carbon projects. In general, better understanding of farmers' perceptions of carbon sequestration, markets and contracts and ensuring that these concepts are distinguished from financial support for development is required. Furthermore, extension services are necessary to increase farmers' understanding of the income benefits associated with trees and improved land-use planning.

REDD+, Communities, Climate Change, Bioenergy

Theme 1: Forests for People

149 - Synergies and Conflicts in the Provision of Ecosystem Services by Small-scale Forest Owners

KG I - 1224 (Uni Freiburg)

IUFRO17-781 **Forest ecosystem services in Germany: how to benefit the private forest owners?**

Dieter, M.* (1); Elsasser, P. (1); Seintsch, B. (1); Franz, K. (1); Selzer, A. (1)

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Abstract: Forests provide a wide range of ecosystem services. Many of these are public goods. Several of our research studies, which can also be found in the German TEEB (The Economics of Ecosystems and Biodiversity) study, provide examples for the economic value of such forest ecosystem services: Measures to improve biodiversity in forests (according to the National Biodiversity Strategy) are valued at 2.2 billion Euro/a by the society. The value of forests for recreation is gauged in the same order of magnitude, at 1.9 billion Euro/a. The value of carbon sequestration in forests, in contrast, is estimated only at 0.1 billion Euro/a, depending on valuation approach. However, property rights for most of these services are allocated at the consumers; forest owners do not share in the high values which their forests provide for society. In contrast, providing protective and recreational services causes substantial costs for private forest owners (42 Euro/ha/a on average). Consequently, it is a goal of German forest policy to offer private forest owners a greater share of the benefits their forests provide. Nature conservation contracts are one of the instruments applied to achieve this purpose. Due to high administrative burdens however, only very few contracts have been concluded up to now. Based on a detailed description of the status quo in Germany and of the pertinent European state aid rules, promising approaches to implement and foster payments for ecosystem services will be presented at the example of nature conservation.

valuation, forest, conservation, contract, private

KG I - 1224 (Uni Freiburg)

IUFRO17-1617 **Awakening of the ecosystem service values of the forest in Japan and Taiwan**

Ota, I.* (1)

(1) University of the Ryukyus, Faculty of Agriculture, Okinawa, Japan

Abstract: This paper aims to describe and compare the policy directions related to ecosystem service of the forest in Japan and Taiwan. Evaluation of economic value of ecosystem services in forest is not common in Japan and Taiwan yet. However, evaluation of public benefit functions of the forest has been done in Japan since 1970s. Water holding, flood control, soil erosion control, landslide protection, recreation and wildlife protection functions were calculated as 75 trillion JPY in total as of 2000. Majority of local governments introduced their own forest tax system in order to facilitate such functions of the forest in recent years. Total amount of tax money that 35 prefectures corrected estimated about 28.8 billion JPY in 2015. Those tax money are spent for thinning of plantation forests, tending of natural forests, extension services, forest education and so on. Importance of public benefit functions of the forest is similar in Taiwan, but recreation and tourism are the only vital utilization of the forest under the strong environmental regulation since 1990. Development of indigenous society related to ecotourism is an interesting policy measure for utilizing state forest in mountainous areas.

ecotourism, forest tax, public benefit functions

KG I - 1224 (Uni Freiburg)

IUFRO17-3502 **A novel approach to forest owner typologies - discourses and power**

Takala, T.* (1); Hujala, T. (1); Tanskanen, M. (1); Tikkanen, J. (1)

(1) University of Eastern Finland, Joensuu, Finland

Abstract: The poor consideration of political and ideological dimensions in forest owner typologies motivated us to create a typology of forest owners' discourses of forest. The term discourse denotes here a set of meanings and ways of speaking that conveys its own kind of truth about forest, forest ownership, and the right way to use forest. We also analysed the order of the discourses in relation to discursive power, and examined how this order places forest owners in societally favourable and unfavourable positions. Our discourse analysis of 24 forest owner interviews combined qualitative content analysis with multivariate methods.

We identified the discourse types of 1) the forester, 2) the economist, 3) the distant economist, 4) the critical anti-economist and 5) the dutiful forest owner. The main gradients separating the types illustrated variation A) from uncertainty to self-confidence in forest management, and B) from pure economic emphasis and non-criticalness to an emphasis on non-monetary meanings and a critique of overriding economic orientation. Economically oriented discourses were interpreted as hegemonic, whereas subordinate discourses emphasised non-monetary forest values.

The results illustrate that the hegemonic truth of forest and forest ownership is still remarkably economic in Finnish society and this marginalises some forest owners.

critical discourse analysis, mixed-methods, NMS

Theme 1: Forests for People

149 - Synergies and Conflicts in the Provision of Ecosystem Services by Small-scale Forest Owners

KG I - 1224 (Uni Freiburg)

IUFRO17-414 **Nature protection payments for forest owners - problem and solution approach from the perspective of the Agency Theory**

Franz, K.* (1)

(1) Thünen Institute, Hamburg, Germany

Abstract: Nature protection in forests is one ecosystem service provided by German forest owners. Since there is no market for nature protection services, financial incentive instruments move more and more in the focus. One objective of such instruments is to balance the interests of nature protection and private forest owners. Within the frame of EU rural development policy there are measures, which address nature protection in forests. But, these instruments so far do not work efficiently.
The presented study analyses the institutional implementation of nature protection payments in the frame of a rural development program with a special focus on the acceptance of the instrument by forest owners. The analytical approach focuses on property-rights-approach and agency-analysis as parts of New Institutional Economics. This perspective systematically analyses the relationship between the parties. The Theory of Planned Behaviour is used as a tool within the agency-analysis to describe the background of forest owners' behaviour.
The main result is that the current instrument is inappropriate for all parties. As a solution approach three result-oriented payment schemes are presented and discussed. Finally the current instrument and the proposed payment schemes are evaluated in a comparative assessment using agency-theory criteria.

PES, private forest owners, Agency Theory

KG I - 1224 (Uni Freiburg)

IUFRO17-337 **Economic Opportunities for Forest Landowners (US) for Ecosystem Services Provided on Privately-owned Lands and Waters**

Jones, D.* (1)

(1) Mississippi State University, Mississippi State, United States

Abstract: Landowners were found to diversify incomes from forests and other lands in US through fee-access outdoor recreation, including hunting, angling, wildlife watching, and other nature-based activities (Jones 2016). The Natural Resource Enterprises (NRE) Program at Mississippi State University educates private landowners, resource agencies, and local communities about recreational enterprises, conservation, and integration of these activities with sustainable forestry and other land uses through educational workshops. Since 2005, the NRE Program has conducted 100 landowner workshops in 12 US states and Sweden and trained in excess of 4,000 participants in outdoor recreational business development and associated conservation practices. Survey results revealed that our programming has initiated over 1,200 new outdoor recreational businesses on an estimated 1.1 million hectares of forest and agricultural lands, generating nearly $17 million in incomes while fostering natural resource conservation on family-owned forests and farms in the US. Given economic incentives, US landowners are more inclined to conduct conservation practices on private lands, thereby enhancing wildlife habitats, water quality and quantity, biologically diverse landscapes, and conservation of natural resources on the land base. NRE development on rural US lands benefits landowners and local communities economically and provides incentives for ecosystem services supported by sustainable forests.

sustainability, forest management, landowners

KG I - 1224 (Uni Freiburg)

IUFRO17-2893 **Estimating the Supply of Ecosystem Services from Small-Scale Forests: Challenges and Opportunities**

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(1) Slovenian Forestry Institute, Ljubljana, Slovenia; (2) University of Tennessee, Knoxville, United States

Abstract: Ensuring a sustainable supply of forest ecosystem services in many parts of the world will depend on private forest owners' willingness to manage for such outputs. While private ownership comprises only 20 percent of the total forest area globally, this share has been increasing over the past two decades, and is likely to continue to grow. Additionally, this ownership class comprises the majority of forest owners in some countries. Private forest landowners may be willing suppliers of ecosystem services, provided appropriate incentives exist, but a number of factors will influence these decisions, including owner and ownership characteristics. While many countries are beginning to implement, or at a minimum consider, policies to encourage private forest owners to adopt management practices that enhance ecosystem services, little information is available regarding how such factors influence their decisions. This presentation will discuss the importance of private forests for timber and key ecosystem services, then review prior research and available national data related to private landowner objectives and management practices, by ownership size and ecosystem service provision. Finally, research needs for estimating the potential supply of selected ecosystem services will be identified, as well as the potential problems in conducting the proposed research.

Private Forests, Ecosystem Services, Management

Theme 1: Forests for People

149 - Synergies and Conflicts in the Provision of Ecosystem Services by Small-scale Forest Owners

KG I - 1224 (Uni Freiburg)

IUFRO17-875 **Paraguay's Atlantic Forest Cover Dynamics and Ecosystem Services Perception; a household survey case study**

Da Ponte, E.* (1); Fleckenstein, M. (2); Parker, A. (2); Oppelt, N. (3); Kuenzer, C. (4)

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Abstract: The Upper Parana Atlantic Forest (BAPPA) Paraguay is one of the most endangered tropical forests in the world. The uninterrupted advance of large mechanize agricultural farming has left less than 10 % of its original cover intact. Despite the fact that rates of deforestation have decreased over the last years the concern still remains. In order to halt the disappearance of the forest, the Paraguayan government put in place several strategies and monitoring programs. One of the most encouraging initiatives is the "Valuation and Retribution of Ecosystem Service Law 3001/2006" (PES).While the concept of ecosystem services has been wildly implemented by policy makers, it is not perceived strongly by the direct users of the forest. Therefore, this study provides a comprehensive understanding how landowners in the BAAPA perceive and use the ecosystem services derived from the forest and what is their influence on forest conservation. The results were obtained from an extensive socio economic household survey conducted at the BAAPA region in January 2016. Landowners are classified into three groups: small-, medium- and large-scale farmers. General outcomes demonstrate that respondent's perceptions and uses of the forest appear to be related to farm size. A strong dependency on forest-related products was observed for small and medium landowners whereas large farmers considered forests main value to be recreational and cultural. Common to all is the understanding of the high ecological value of the forest and the impact of its disappearance. PES appears to be a well-accepted by forest owners, however a higher promotion must be given, in particular among large-scale farmers group. Overall, interviewees supported the current environmental laws but remarked the crescent corruption among environmental authorities. Understanding the social value given to ecosystem services is a valuable contribution towards to the development of measures aimed at conserving natural resources.

BAAPA, PES, perception, household-survey

KG I - 1224 (Uni Freiburg)

IUFRO17-1610 **What Accounting System and Accountancy Network Can Tell Us about Financial Consequences of the Provision of Ecosystem Services**

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Abstract: In Central Europe the role of forest based ecosystem services (ESS) has increased over the past decades. Step by step, it became evident that the understanding of the backwash theory - arguing that the provision of ESS is part of a "normal", timber focused forestry - is no longer applicable.

In 2003 a system of so called product ranges was introduced by the German Council of Forestry, in order to depict the proceeds and the income related to different ESS. This accounting system is introduced and discussed in terms of its accuracy and applicability for different entrepreneurial settings. The development of various proceeds and outlays in different ownership types is presented.

On first sight it seems to be evident that so far the provision of ecosystems services does not play a substantial role for most parts of the forest enterprises. The share of outlays and proceeds of product ranges like "conservation and restoration" or "education and environmental education" are comparatively low and have only developed slowly over the past decade. Based on these results it will be shown that there are two types of problems related to this system. The concept of multipurpose forestry impedes the subdivision of outlays and proceeds into different product ranges. Moreover it becomes obvious that it is frequently not the direct costs that are most relevant for the long term profitability of forest enterprises. The major role of opportunity costs related to restrictions caused by ESS is additionally introduced and compared with the present role of direct cost related to ESS.

Based on these findings initial thoughts on concepts for the integration of opportunity costs into accounting systems are introduced and discussed. A major part of this approach is a typologization of different framework-conditions and the introduction of some kind of overhead-calculation for these different types.

Theme 1: Forests for People

176 - Agroforestry - the future of land use management?

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1383 **Truffle cultivation as an alternative for agroforestry in Poland**

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Abstract: Truffles are highly prized fruit bodies of subterranean fungi, which always occur in ectomycorrhizal symbiosis with host plants (mostly oak, hazel, hornbeam etc.). The Burgundy truffle (Tuber aestivum) fruitbodies are being soldfor the equivalent of about 200 to 700 euros a kilogram, however market prices depend on seasonal demand and may exceed even 1000 Euro/kg. Taking into account potential profits, costs of truffle orchard's establishment (about 5000 Euro/ha) and management (1200 Euro/ha year) seems to be relatively low.
Cultivation of truffles can be also a form of ex situ conservation of the species. Trees and shrubs outplanted in truffle plantations provide habitat for many species of wildlife (including insects, birds and small mammals) in the open farm lands. Associated benefits include also prevention of soil erosion, biomass production and modification of energy flow through the ecosystem.
Experience from other countries showed that truffle cultivation requires relatively low agricultural inputs, promotes reforestation and economic restoration as well as land-use stability of rural lands. Cultivation of truffles can become important alternative for agriculture in rural regions, especially in relatively harsh conditions. In the last decade, the interest in truffle cultivation increased greatly in Poland.

agroforestry, Tuber aestivum, truffle cultivation

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1474 **Nutrient response and nutrient retention efficiency in temperate agroforestry systems**

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Abstract: Agroforestry systems are innovative agricultural systems, which take advantage of beneficial ecological functions of their components, aiming to attain high productivity with possibly less negative environmental effects, e.g. nutrient and carbon losses. However, no comparison of nutrient response and retention efficiencies has yet been conducted between conventional and agroforestry systems. Our study aimed 1) to quantify nutrient response (ratio of biomass production to soil available nutrients) and nutrient retention efficiency (1-leaching losses/soil available nutrient) in conventional and agroforestry systems, and 2) to assess if competition and/or facilitation exists between tree strip and grass/crop in agroforestry systems. We hypothesized that conventional systems will have lower nutrient response and retention efficiencies than agroforestry systems.
Our study investigated six paired sites of grassland/cropland and agroforestry with alley cropping of fast growing tree species and crop/grass, located in central and eastern Germany. Measurements in agroforestry were taken within tree strips and at various distances to the tree strips within the crop/grass strips. Results from the 2016/2017 growing season will be presented. This study will provide the presently needed information on whether agroforestry can reduce the negative environmental impacts through gaseous/leaching losses while optimizing production and therefore might be a sustainable alternative to conventional agriculture.

Nutrient response/retention efficiency

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-4125 **Agroforestry a tool to mitigate climate change**

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Abstract: Nowadays, farms are claimed to deliver healthy products from sustainable land use, while being resilient to climate change and provide management options that mitigate climate change. European Union normative 529/2013 highlights the importance that Agriculture should have in reducing emissions, mainly through the implementation of Agroforestry in arable lands but also through the introduction of woody perennials, therefore agroforestry in permanent areas grasslands. However, agroforestry has also to play a role in the improvement of forestland resilience mainly related with the use of silvopastoral practices in those areas where fire risk is high. This paper evaluate the different forms that agroforestry can contribute to climate change and the potential area where agroforestry can be implemented.

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-808 **Bundles of ecosystem services provided by agroforestry in European landscapes**

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Abstract: Temperate agroforestry systems are known for food and timber production, soil protection, carbon sequestration and at the same time as semi-natural habitats for flora and fauna. In short, they provide a bundle of different ecosystem services (ES). The European FP7 project "Agroforestry for Europe - AGFORWARD" focuses on these ES, notably on biophysical yield, soil protection, water and nutrient cycle, carbon stock and sequestration and on biodiversity aspects like pollination, habitat, and species richness.
We developed a conceptual framework to evaluate those ES at the landscape scale, accounting for the relevant spatial and temporal scales. The approach was established for traditional fruit tree orchards in Switzerland. Based on 8 to 12 typical landscape test sites (1 sqkm each); habitats were mapped and soil, climate and management information was collated. This data were used to measure and model ES, evaluate synergies and trade-offs between different ES and visualize the landscape and time effects. Subsequently the approach will be applied to twelve European case study regions in France, Germany, Greece, Rumania, Spain, Sweden, and UK.

Ecosystem Services, Agroforestry, Biodiversity

Theme 1: Forests for People

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Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2808 **Conservation benefits of tropical multifunctional land-use in and around a forest protected area of Bangladesh**

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Abstract: Competing interests in land for agriculture and commodity production in tropical human-dominated landscapes make forests and biodiversity conservation particularly challenging. Establishment of protected area in this regard is not functioning as expected due to exclusive ecological focus and poor recognition of local people's traditional forest use and dependence. In recent years, multifunctional land-use such as agroforestry have widely been promoted as an efficient land-use in such circumstances, although their conservation effectiveness remains poorly investigated. We undertook a rapid biodiversity survey to understand the conservation value of four contrasting forms of local land-use, namely - betel leaf (Piper betel) agroforestry, lemon (Citrus limon) agroforestry, pineapple (Ananus comosus) agroforestry, and shifting cultivation fallow managed largely by the indigenous communities in and around a highly diverse forest protected area of Bangladesh. We measured the alpha and beta diversity of plants, birds, and mammals in these multifunctional landscapes as well as in the old-growth forest in the area. Our study finds local land-use critical in conserving biodiversity in the area, with comparable biodiversity benefits as those of the old-growth forest. In Bangladesh, where population pressure and rural people's dependence on forests are common, agroforestry land-use in areas of high conservation priority could potentially be used to bridge the gap between conservation and commodity production, ensuring that the ecological integrity of such landscapes will be altered as little as possible.

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-704 **Homestead agroforestry for forest conservation and ecosystem services - A case in the deforested area of Bangladesh**

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Abstract: Ecosystem services are the benefits that people receive from nature. In the recent years, a big decline in biodiversity is observed due to human activities, and species are becoming extinct much faster than at any time in the past. Like many other countries, Bangladesh also lost a large number of natural resources due to deforestation and other anthropogenic activities. Homestead is a diversified and complex production system that provides various services and functions. A total of 50 households near Teknaf reserved forest were surveyed from June to August 2016 to investigate the causes of deforestation and ecosystem services from a homestead of southeast region of Bangladesh where deforestation is a big concern. It was observed that over exploitation of resources for firewood and betel-leaf farming are two major causes of deforestation. The data revealed that 66% of the tree species in homesteads were native. Tree density was high (776 trees/ha) in a homestead due to dominance of betel nut tree, which was planted densely. However, the Shannon Index (0.67) indicates a low tree diversity. A large numbers of crop, tree, poultry and livestock were found in homestead that supply vegetables, fruit, timber, fodder etc. All the households use firewood for cooking, of which only 26% are supplied from homesteads. A well-designed homestead could accommodate more trees, crops and animals for various ecosystem services and functions and ultimately restore forest ecosystem and biodiversity.

Homestead, Ecosystem services, Biodiversity

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1443 **On-farm tree products: How reliant are smallholder farmers on this resource for subsistence needs?**

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(1) Bangor University, Bangor, United Kingdom; (2) World Agroforestry Centre, Nairobi, Kenya; (3) Bangor University, World Agroforestry Centre, Nairobi, Kenya

Abstract: In many parts of the world, population growth and agricultural expansion have led to a reduction in uncultivated or 'wild' areas and increasing pressure on land to meet multiple needs. Here we explore the roles that trees play in smallholder livelihood strategies in such places. In January-March 2016 a questionnaire was administered to 160 smallholder households (from 0.3-9.3 ha in size) across Namabya Sub-county, Manafwa District, Eastern Uganda. Three main sources of tree products were utilised by local people. In order of importance these were: own farm; purchased from markets; gifted by neighbours/relatives. Only three households reported harvesting from surrounding land or wild areas. There was high reliance on tree fruit and firewood from own farms for subsistence needs (87.5% households sourcing >=50% tree fruit; 77.5% households sourcing >=50% firewood from own farms). The proportion of tree products used for subsistence needs from each source did not differ between households of different wealth classes. To be effective, rural interventions must consider the full range of subsistence-based farming families' needs and recognise and support the role that farmer-owned trees play in meeting these needs, in addition to consideration of their provision of global, off-farm, environmental services.

Uganda, agroforestry, livelihoods, tree products

Theme 1: Forests for People

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Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2706 **Assessing the adaptation to climate change of agroforestry systems by field experiments and numerical simulations.**

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Abstract: Climate change is a threat to many crops in Europe. Early spring thermal and water stresses occur more and more frequently and are considered as a main limit to crop yield increase in Europe. Agroforestry systems with mature trees have the potential to modify the microclimate of crops grown in agroforestry alleys. The experimental assessment of the impact of agroforestry microclimate on the resilience of crops is difficult : the climate should be modified experimentally, which is not easy at the scale of an agroforestry system.

We address this issue by a dual approach linking field experiment and the use of numerical models. We set up a mobile rain exclusion device in a mature walnut-wheat agroforestry system in South France. This is a unique experiment so far in Europe. Simultaneously, numerical simulations of agroforestry systems facing various climate scenarii are performed with the HisAFe model.

Results presented were obtained during the first growing season since the rain exclusion device is operational. We analyze the climate modification in agroforestry and compare the crop behavior in an open control field, an agroforestry stand with the normal rainfall, and an agroforestry stand with a reduced rainfall. Simulation runs are compared to the experimental results and allow to predict the long term trend of crop behavior in agroforestry systems.

water stress; thermal stress; tree shade; HisAFe

Theme 1: Forests for People

80 - Changing Forest Ownership: significance of trends and implications for management and policy

KG I - 1228 (Uni Freiburg)

IUFRO17-3715 **Forest ownership in the ECE region: What do we know? Results from the Joint COST Action FACESMAP/UNECE/FAO Enquiry on Forest Ownership in the ECE Region**

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Abstract: This presentation aims to give a state-of-art report on what is currently known about the forest ownership structure in the ECE region. It mainly relies on the dataset of the Joint Enquiry on Forest Ownership in the ECE Region, carried out by the COST Action FP1201 FOREST LAND OWNERSHIP CHANGES IN EUROPE: SIGNIFICANCE FOR MANAGEMENT AND POLICY (FACESMAP) and UNECE/FAO in 2015/2016 and which collected information on the impact of forest ownership types on economic, ecologic and social aspects of forests. On the basis of quantitative and qualitative information we describe the distribution of public and private ownership types and their trends but also analyze how forests under different ownership types differ and how forest management systems are influenced by different types of forest ownership.
The value of this study is among others in the unique combination of official up-to-date statistical information as well as scientific studies on ownerhip types, and in the analysis by international and interdisciplinary analysis teams. The dataset behind the presentation is publicly available for further scientific analyses and provides important background information for political decision makers.

statistics, quantitative and qualitative analysis

KG I - 1228 (Uni Freiburg)

IUFRO17-2554 **State Forest Management Organizations in Europe: performance, potential and challenges**

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Abstract: State Forest Management Organizations (SFMOs) are playing an increasing role in the European forest sector managing almost a half of forests in the region. SFMOs are often managed for the purpose of timber production, while being publicly owned they play an important role in providing a vast range of public goods, like soil protection, biodiversity conservation, landscape maintenance, etc. In several European countries, the future of forests and forest-related resources strongly depend on the direction of SFMOs' development, included their strategic vision and management capacity. However, there is a lack of knowledge about the current performance of SFMOs, as well as recent changes into their management priorities, goals and practices in response to the new demands expressed by the society (e.g., accountability, transparency, social inclusion, etc.). The main purpose of the study is to analyze the current situation of SFMOs in Europe with respect to these issues.
The analysis is based on SFMOs members of EUSTAFOR, their European association. Data was collected from official reports, questionnaires and interviews. The content analysis technique was used for analyzing information. A large set of characteristics has been processed with the help of benchmark and cluster analysis.
Preliminary results show that there are two main groups of SFMOs in Europe. The first group is applying technological and organizational innovations (e.g., mechanization, outsourcing, development of advanced logistic systems) and became mainly profit seeking. The second one is involved in the process of property restitution and sees itself as the protectors of the public interest and does not get involved in forest management from a business point of view.

State forest management organization, Europe

KG I - 1228 (Uni Freiburg)

IUFRO17-2272 **Forest advisory systems for changing forest owners in Europe**

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Abstract: Traditionally government extension officers have advised and instructed farmers and forest owners. However the situation with forestry is diverse, complex and evolving. We develop a 'forest advisory system' analysis to help understand patterns and change in ten countries in Europe, based on: (1) knowledge and information as a system; (2) the distinction between knowledge transfer and knowledge exchange; (3) choice of instruments in environmental policy. We apply this analysis to qualitative data collected from experts and group reflexive processes from the ten countries.

Instead of traditional forest extension services we find forestry advice is provided by a mix of actors from the state, private and NGO sectors. The policy context in which this advice is delivered varies widely, and does not show consistent geographical patterns of change that fit, for example, with political change. In all countries we see a shift towards reduced regulatory control and a more participatory approach, diversification and liberalisation of information, and an open market in terms of advice. This raises new questions of expertise, reliability and accuracy of information, and trust between actors. Furthermore, the advisory system is not simply a link between policy and owners, but a more complex set of interactions between stakeholders.

Some FASs try to take into account diversity of forest owner profiles in order to adapt advisory offer and demand, but in many countries the providers of advice do not know the owners and their objectives very well. We conclude with recommendations for linking forestry knowledge and policy in the changing European context.

forest extension, policy tools, regulation

Theme 1: Forests for People

80 - Changing Forest Ownership: significance of trends and implications for management and policy

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IUFRO17-3312 **Towards impact and inclusiveness with forest owner related policies**

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Abstract: Forest ownership changes have often constituted a perceived threat to wide benefits from forests. Public policies have responded, for example, by means of forestry subsidies, communication campaigns, restrictions to land sales, and support to forest owners' associations. Large body of evidence from policy evaluation studies informs varying effectiveness of these efforts.

This contribution analyzes the state-of-art of forest-owner-related policy changes in Europe and prevalent challenges for policy renewal. The analysis is based on versatile interview and survey data, expert assessments and stakeholder workshops organized in 2012-2016 within the COST Action FACESMAP. An essential source of summarized evidence is the compilation of 28 country reports produced in the Action.

There is a liberalization trend in forest policies in Europe, including privatization and decentralization (e.g., Germany, UK) and a market liberalization of services (e.g., Finland, Romania). Some indications suggest that bottom-up and participatory approaches suit well to reach and motivate diverse owners, in combination with regulatory and financial means.

Functioning land markets could better (than strict land consolidation policies) direct forests into the hands of actively interested owners. Incentivizing towards more diverse use of forests may lead to refining property rights, which is not free from tensions between land owners and other users.

When streamlining the policy portfolio with emphasis on effectiveness and coherence, attention needs to be paid to the policy response by new and emerging forest owner types. A better knowledge of forest owners' goals may be the key to solving many of the problems in the implementation of forest-related policies.

bottom-up governance, deregulation, policy tools

KG I - 1228 (Uni Freiburg)

IUFRO17-3192 **Combining data on ownership characteristics, forest condition and management activities - A database for improved understanding of small-scale forest owner's behavior**

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Abstract: Given the changes amongst the small-scale forest owners and within the forest policy, are an increasingly pronounced interest not only to observe and describe, but also to understand the dynamics of the private individual forest ownership. We work on expanding a previously developed and statistically significant ownership and property-level model of the individual-owned forest in Sweden. The model is based on an objective sampling of forest holdings based on the Swedish Forest Agency's annual survey of owners' self-activity in small-scale forestry.
The estimation of the forest conditions for each forest holding in the database, will be based on existing data from processing of laser scanning. Forest condition will be described per segments similar to stands.
Data from the survey and the description of the forest will be combined in a database, and further expanded with a new survey to the owners with detailed questions about ownership, how decision are made, motives, benefits, and forest management plans.
This new database creates conditions for examining the relationships between forest owners' ownership, attitudes, etc., their behavior; actual measures and the state of the forest. This new model gives opportunities for researchers to conduct a variety of analyzes.

small-scale forest owner, management, forest

KG I - 1228 (Uni Freiburg)

IUFRO17-1655 **Living and working at several places: the "new" forest owner in Sweden**

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Abstract: Small-scale/non-industrial private forest owners of today are, compared to previous owners, increasingly living away from their land, and are to a higher degree urban, female and inheriting their forest. While forest has so far been little emphasised in rural studies, this summary of a Swedish project, in cooperation with FACESMAP authors, shows that a focus on "new" forest owners can help us understand both rural and urban change across Europe. For the Swedish case, it shows upon a population that to varying extent share their time between rural and urban areas and residences, and use their forest for multiple and varying purposes. Conceiving of countryside in terms of mobility rather than as de-populating may thus provide an added layer of understanding of how people are not "either or" (urban or rural), but rather "both and". The study also discusses potential implications of this with regard to taxation systems and policy development for maintaining a living countryside.

Forest, forest owners, Sweden

Theme 1: Forests for People

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IUFRO17-1667 **Spider web of ownership relations in the Czech forests**

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Abstract: The state of forests in the Czech Republic (which cover about 1/3 of the total area) is influenced by many factors. One of the most important is the ownership structure. Current structure resulted from the restitution process, whose effect is the re-establishment of property rights on one hand and significant fragmentation of private forest ownership on the other. The input data were obtained from the Czech Geodetic and Cadastral Office (more than 2.6 mil records). These data were parsed in Python 2.7 and subsequently analysed in MS Access 2010, ArcGIS 10.3 and R 3.1.2. In the first scrutiny we have focused on physical persons as private forest owners. There are about 350 thousand individual private forest (co)owners who owned 17,5 % of Czech forests. Only 106 people own property larger than 250 ha. The average size is 1,28 ha, median only 0,25 ha. The average distance of the property from the owner's residence is 23,5 km. Women represent 44% of all natural persons; own, however, only 32 % of the total area. The largest share (26%) own people born in the years 1951-1960. Property fragmentation and decrease of traditional owners (i.e. those living close to their forests) could be potential risk for the sustainable forest management. The complete knowledge of the ownership structure is thus essential for the forest policy measure planning.

Ownership structure, forestry, Czech Republic

KG I - 1228 (Uni Freiburg)

IUFRO17-3126 **Status and challenges of small-scale private forest management in actual ecological and social circumstances - Croatia case study**

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Abstract: The forest management in Croatia has been focused and adapted to state forests for decades. Unlike state forests, private forests have not been embraced with consistent and sustainable system of forest planning and management on satisfactory level. This is consequence of relative small share of private forests and historic circumstances of forestry development. Past restrictions on size of forest property, encouragement of negligence for forest property and absence of active and appropriate forest management during the second half of 20th century resulted with large number of forest owners with very small forest estates scattered in several parcels. Recent process of restitution to former owners is intensifying which results in appearance of larger private forest property. There is also an increase of medium size forest estates partially as a result of property resumption as well as afforestation of agricultural land due to depopulation of rural areas. Therefore, the share of private forests is expected to reach 30% of area, with concurrent increase of their structural quality, as indicated in the results of first Croatian NFI. These facts enforce requirements for more active and efficient private forest management trough implementation of an appropriate forest guidelines and forest management models within consistent system of forest management planning and forest strategy. Thereat, challenges such as optional management prescriptions, uneven-aged and multi-aged management systems, large number of inactive forest owners, right of individual perception of forest management, low quality and degraded structures of private forests, problems with land register etc. are relative new for Croatian forest profession. The recognition of an actual status, analyses and models of possible solutions from Croatian perspectives are presented in this work.

forest management,property size,forest owners

Theme 1: Forests for People

183 - Forest Education

Room "Colmar" (Novotel Freiburg)

IUFRO17-3504 **Connecting FAO and University Educators for Effective Forestry Education**

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Abstract: The FAO is active in strengthening country capacity for participating in the REDD+ under the UNFCCC with the overarching goal to improve forest management and reduce emissions with international policy incentives that address deforestation and forest degradation. Here we relate our experiences in tapping the strengths of university educators working in collaboration with FAO to create effective capacity building / teaching programs for forest technicians and administrators building toward REDD+ participation. We learnt that students responded best to learning environments where policy and technical expertise is tempered with teaching methodologies based on a good understanding of the student experience and a recognition of teaching being all about people. There is rich potential for building collaboration between the FAO and Universities to improve forest management and the capacity building goals - and more broadly in forest education. Given the global importance of improving forest management it is essential that the FAO and universities recognise each others strengths and work together.

Room "Colmar" (Novotel Freiburg)

IUFRO17-2001 **Creating the best joint educational platform in forestry - Case study: 3+2 transfer programs between UBC and partner universities in China**

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Abstract: Forestry education has been drawn great attention in the past decade. Facing low student enrolment rates, reduction in funding, and declining demand for forestry graduates, many forestry institutions have adopted strategies to attract more students by changing curriculums, offering international learning experiences, developing partnerships with industries, and networking with research institutes. In the midst of reforming forestry education, the UBC Forestry has developed a successful joint educational platform with forestry universities in China. The platform aims to help forestry institutes share high-quality educational resources and methods, cultivate qualified research and management personnel in forestry sector with bilingual skills and cross-cultural understanding, enhance faculty exchange and research cooperation, promote capacity building, and provide opportunities for developing more diverse educational programs. Since 2008, over 220 students have participated in these programs and received great learning experiences. Many of them have graduated and now are studying in graduate schools or working in forestry sector. This platform has also promoted student mobility, faculty exchange, research cooperation, capacity building and training programs. This presentation will summarize the experiences in developing this platform, impacts and benefits, issues and strategies. We believe the lessons learned from this special case will benefit others in developing international partnerships.

international, education, partnership, capacity

Room "Colmar" (Novotel Freiburg)

IUFRO17-2943 **Practitioners' Experiences and Perspectives on Learning and Education for Future Forestry**

Pohlschneider, S.* (1); de Lima, P. (1); Grey, D. (2); Ambrose-Oji, B. (3)

(1) University of the Hihglands and Islands, Inverness College, Inverness, United Kingdom; (2) University of Aberdeen, Aberdeen, Germany; (3) Forest Research, Bristol, Germany

Abstract: Forests world-wide make a fundamental contribution to various environmental, social and economic objectives, but are subject to uncertainty and complex changes in the future. More than ever forestry education institutions are urged to educate future forestry professionals who have the capacity to cope with the challenges to come. Disconcertingly, the British forestry sector appears to be experiencing a rising demand for a skilled workforce while student interest in forestry careers is declining. Thus, improving recruitment and providing future practitioners with relevant education are a major concern for British forest interests.
Most studies in the field of forestry skills and recruitment in Great Britain represent institutional perspectives on the supply side, i.e. forest industry and universities. Providing an alternative approach, this on-going qualitative study elucidates forestry professionals' experiences and opinions around career paths, skills issues and future forestry across British forestry. In-depth interviews conducted provide the basis to conceptualise and contextualise participants' experiences in the broader discourse by applying a socioecological lens. Understanding practitioners' views is a step towards a more holistic concept of forestry fit for the 21st century. The fieldwork for this project was completed in September 2016 with data analysis taking place in early 2017.

Forestry education, qualitative research

Theme 1: Forests for People

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Room "Colmar" (Novotel Freiburg)

IUFRO17-3387 **Behavioral Event Interviews (BEI) related to skills and capabilities needed in current forest sector - results from the Global Outlook on Forest Education**

Rekola, M.* (1); Abbas, D. (2); Bal, T. (3); Burns, J. (4); Lackner, M. (5); Paulus, C. (6); Rodríguez-Pineros, S. (7); Sharik, T. (3); Storer, A. J. (3)

(1) University of Helsinki, Department of Forest Sciences, Helsinki, Finland; (2) Warnell School of Forestry and Natural Resources, University of Georgia, Athens, United States; (3) School of Forest Resources and Environmental Science, Michigan Technological University, Houghton, Michigan, United States; (4) International Union of Forest Research Organizations (IUFRO), Wien, Austria; (5) International Forestry Students Association (IFSA) , Freiburg Im Breisgau, Germany; (6) Lifelong Learning and Continuing Education, University of Natural Resources and Life Sciences (BOKU), Wien, Austria; (7) Faculty of Animal Science and Ecology, Autonomous University of Chihuahua, Chihuahua CP, Mexico

Abstract: The forest sector is globally under changes due to several drivers such as climate change, political instability, aging societies, and bioeconomies. All these drivers have had considerable impacts on forest sector in general, and more specifically, on the required competencies of people working in this field. There is an increased demand for social, management and governance skills among other generic skills. The importance of this type of non-forest specific professional skills have been stressed in several studies. To date these studies have been empirical ones they have mainly been based on rankings and/or ratings data on skills and competences in a survey context. There seems to be two missing aspects in the previous research. First, there are needs to enhance the deep understanding about the role and structure of skills and capabilities as wells as the concreteness of these results from the point of view of education and working life. Second, there is a need to apply the research methodologies for human resource (HR) studies within forest sciences. For instance the competence studies and job analysis, widely used in HR research, would be useful in analyzing forest sector professionals.
The Global Outlook on Forest Education (GOFE) project has made a competence analysis with the HR-specific Behavioral Event Interview (BEI) method. This method applies in-depth interviews that target recent graduates and documents their professional life needs. The aim is to reveal the needed critical skills, both forest subject related and generic. The outcomes of the study are expected to enable comparisons across different countries and curricula, and potentially enrich the development of tertiary forest education perspectives, as well possible contribution for new life long learning courses in the forestry sector. The results are envisioned to contribute to the development of a more current approach to forestry education and a more dynamic view of the field.

forest education, interviews, competencies

Room "Colmar" (Novotel Freiburg)

IUFRO17-3407 **A review of Forestry Curricula in South African tertiary institutions**

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(1) University of the Witwatersrand, Johannesburg , South Africa

Abstract: Globally, forests are currently under pressure due to a range of social, economic and environmental drivers including war, globalisation of markets and climate change. These pressures have created new trends in the structure of forestry curricula that are reflected in labour markets and the consistent demand for forestry graduates to acquire a broad array of skills and experiences. In response to the afore mentioned pressures, forestry education needs to consolidate traditional forestry programmes with other disciplines as well as develop social capital and the need for non-technical skills in order to overcome emerging challenges. The aim of this research is to highlight the range of curricula and improve our understanding of forestry education programmes in South African tertiary institutions with a focus on assessing whether the needs of the sector are being met. In this study, curricula are categorized as Forest Science and Multiple Ecosystems. To determine whether there is a difference between the two curriculum structures, the study compared the learning outcomes of Forest Science programmes with those of Multiple Ecosystems programmes. Furthermore, Behavioral Event Interviews were conducted as a method to understand the competency of the students acquiring these qualifications. To conduct a gap analysis between curriculum experts and forestry employers, the study used some of the graduate attributes listed in the most recent baseline study on South African graduates from the perspective of employers. The analysis of this study is a work-in-progress; we hope that our results will provide an opportunity for South Africa to contribute toward Africa's participation in this global effort of forest preservation.

forestry education; competency; curriculum

Room "Colmar" (Novotel Freiburg)

IUFRO17-2471 **Analysis of competences of a Forestry engineering program: A case of Colombia**

Villarraga, L.* (1); Rodriguez, S. (2); Ceballos, K. (1); Angarita, F. (1)

(1) Universidad Distrital Francisco José De Caldas, Bogota, Colombia; (2) Universidad Autónoma de Chihuahua, Chihuahua, Mexico

Abstract: Colombian forest ecosystem is considered one of the most biodiverse of the world, 54% of its area corresponds to natural forests; however, its depletion has been a challenged for government and educational institutions. There are 14 institutions that included forest education, five traditional forestry-engineering programs; and the rest are technical or agroforestry schools.

This study focuses on the forestry engineering program of Universidad Distrital, the oldest of Colombia, which currently has more than 2000 graduates contributing to the sustainable management of the forests. The aim of the study is to analyze the competencies established by this program. Initially, a survey will be carried out on about 100 newly graduates to explore their opinion about competences acquired in the University and the classrooms. Then, through the BEI methodology, at least 30 graduates will be interviewed to identify and evaluate the competencies needed in their working life. This work intends to have tools to propose possible changes that may be necessary to strengthen the skills of forest program graduates and to contribute to the IUFRO's Global Outlook on Forest Education Research Project (GOFE). This research is in process and final results are expected in June 2017.

Forest Education Competences, BEI, Tropical Forest

Theme 1: Forests for People

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Room "Colmar" (Novotel Freiburg)

IUFRO17-3836 **Swedish forestry education for the 21st century. - A case study on graduates from Swedish forestry schools.**

Lundsten, J.* (1)

(1) Swedish University of Agricultural Sciences, Umeå, Sweden

Abstract: There is a rapid change in the world on how we look at our natural resources and how to manage them. The forestry profession is undergoing a shift and has to keep up with this changing environment.

This study aims to answer the question: Do Swedish forestry schools have a curriculum that matches the demand from working life after graduation?

The method of behavioral event interviews will be used on gradate students from the Swedish University of Agricultural Sciences forestry programs in their professional working lives. Together with a curricula analyze in order to do a GAP analysis.

The anticipated outcome is that soft soft skills such as communication and people skills are competencies that graduated foresters are lacking, together with problem solving abilities, in order to achieve success in their work life.

Looking at the program evaluation done among Swedish forestry students in 2016, one can conclude that a better and more up to date forest education is much needed.

graduate, forestry, competencies, education

Theme 1: Forests for People

164 - How forest investment science can support sustainable forest management?

KG I - 1199 (Uni Freiburg)

IUFRO17-1513 **Origins and Sustainability of Institutional Timberland Investing**

Caulfield, J.* (1)

(1) Warnell School of Forestry and Natural Resources, University of Georgia, Athens, Georgia, United States

Abstract: Proposed session: No. 164, "How forest investment science can support sustainable forest management"

Abstract title: Origins and Sustainability Impacts of Institutional Timberland Investing

Authors: Jon P. Caulfield

Key words (up to 5): institutional investors; TIMOs; sustainability; planted forests

Abstract: Acquisitions of timberland by TIMOs for institutional investors began in the United States in the early 1980s. Original participants consisted almost exclusively of U.S. pension funds, endowments, foundations and high-wealth individuals. Since then, and particularly since the Great Recession, the asset class is witnessing broader acceptance by non-U.S. investors. While the U.S. remains the primary investment destination, there is increased activity elsewhere in the world. To date this is primarily in Oceania and Latin America, but investments are also being directed toward Europe, Africa and Asia.
Greater institutional participation in timberland is accompanied by rising expectations for TIMOs to manage forests in a manner that promotes long-term sustainability. In practice, this can come in the form of acquiring planted forests, which produces several positive externalities. First, it reduces demand pressures on natural forests. Second, in countries which formerly had depleted forests (e.g. Uruguay), or little natural forest to begin with (e.g. South Africa) planting trees has led to the development of home-grown forest-based economies which raises employment, GDP, and increases the diversity of the domestic economy. Third, in countries where land tenure is not well-defined, the acquisition of private forests serves to reinforce the discipline of legally well-defined property rights, a prerequisite to a properly functioning market system.

KG I - 1199 (Uni Freiburg)

IUFRO17-1727 **Timberland investing and forest conservation and sustainability**

Morales Olmos, V.* (1); Siry, J. (2)

(1) University of the Republic, University Center of Tacuarembo, Tacuarembo, Uruguay; (2) University of Georgia, Warnell School of Forestry and Natural Resources, Athens, United States

Abstract: The lack of funding for sustainable forest management (SFM) is one of the reasons why global forests' ability to meet our economic and environmental goals has been in doubt. While governments and international aid organizations provide funds for these purposes, it is apparent that the needs greatly exceed available funding. Public and private forest investment programs offer another source of SFM funding as they contribute to increasing forest area, rely on science-based forest management, and practice forest certification. This presentation will analyze the consequences of the forest investment programs undertaken in the last few decades for forest conservation and sustainability goals around the world, including sector-wide examples from South America, the United States, Europe, Oceania, and other regions. The presentation will conclude with a discussion of the economic and environmental impact analysis of forest investments and a development of policy implications based on the findings.

investments, sustainability, forest management

KG I - 1199 (Uni Freiburg)

IUFRO17-2386 **Achieving Forest Sustainability from an Operator's Perspective**

Thomas, M.* (1)

(1) F&W Forestry Services, Inc, Albany, United States

Abstract: F&W Forestry Services is an international forestry consulting firm, which has been providing on-the-ground forest operations management services to timberland owners since 1962, and to Timberland Investment Management Organizations since the mid 1980's. An important application of timberland investment management principles is carried out by the actual operators of the property, including assisting clients to determine sustainable harvest levels; implementing those harvests on the ground; obeying applicable legal and certification (SFI, SFI, PEFC, ATF, etc.) constraints; protecting threatened and endangered species, soil and water; monitoring wood security and property security; and establishing viable and productive plantations and in some cases natural regeneration. While tree species, laws, culture, business climate and weather vary from country to country, the basic principles and management techniques necessary to achieve financial and environmental sustainability are the same around the world.

Forest operations;sustainability;

Theme 1: Forests for People

164 - How forest investment science can support sustainable forest management?

KG I - 1199 (Uni Freiburg)

IUFRO17-2688 **A Lender's Perspective on Forest Investments**

Schlesinger, R.* (1)

(1) Prudential - Timberland Capital Group, Roseville, United States

Abstract: Prudential Financial, Inc. (NYSE: PRU) is a financial services leader with $1.2 trillion of assets under management, serving institutional and individual customers in the United States, Asia, Europe and Latin America. Timberland Capital Group, a part of Prudential Agricultural Investments (PAI), originates and manages timberland loans for Prudential and other investors. With average loan of $25 million, it serves institutional and family ownerships with a full range of structuring scenarios. Financial organizations have been attracted to timberland investments due to its attractive cash flow characteristics and diversification benefits. This presentation discusses unique attributes of timberland mortgages including non-depreciable asset (biological growth, non-perishable crop, timing harvest, and sustainable harvest levels) and investment performance (high performance assets, stable land values, large investments, investor transparency and management, and regional diversification). It recognizes timberland market as a growing investment segment and provides an understanding of considerations for leverage. Recognizing the lack of funding for sustainable forest management (SFM) as a persistent problem, financial organizations offer another source of SFM funding by contributing to increasing forest area, rely on science-based forest management, and practice forest certification while generating attractive financial returns.

forest investment, finance, sustainable forest mgt

KG I - 1199 (Uni Freiburg)

IUFRO17-1542 **Educating timberland investment professionals**

Izlar, B.* (1)

(1) University of Georgia, Langdale Center for Forest Business, Athens, United States

Abstract: Since 1985, the University of Georgia Warnell School of Forestry and Natural Resources has offered graduate degrees with a blend of advanced forest investment/operations courses and MBA-level courses in the University's Terry College of Business. That effort was formally codified in 1997 with the establishment of The Harley Langdale, Jr. Center for Forest Business in the Warnell School. The Langdale Center offers a non-thesis masters, MS and PhD degrees in forest investment science. Langdale Center alumni are employed throughout the forestland investment space from financial institutions to consultancies to pension funds to fund managers. Also, the Langdale Center has conducted a series of world-class Timberland Investment Conferences on a regular basis since 2004 in the US and abroad. These conferences have showcased Langdale Center students, faculty and research to the forest investment science world.

timberland investment, forest business,l education

Theme 1: Forests for People

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Room "Colmar" (Novotel Freiburg)

IUFRO17-3607 **Planned educational infrastructure in Kutno Forest District (Poland)**

Blasiak, A.* (1); Krokowska-Paluszak, M. (1); Daszkiewicz, J. (2); Wala, Z. (3); Gruchala, A. (4); Skorupski, M. (1)

(1) Department of Game Management and Forest Protection, Faculty of Forestry, Poznan, Poland; (2) Department of Grassland and Natural Landscape Sciences, Faculty of Agronomy and Bioengineering, Poznan, Poland; (3) Kutno Forest district, Regional Directiorate of SF in Ludz, Lanieta, Poland; (4) Forest Economy, Faculty of Forestry, Warszawa, Poland

Abstract: Nature educational trials play a significant role in the educational process. They allows to transfer the natural knowledge through the contact with nature. However, only correctly organized, interesting pathways are able to be interesting for visitors. The aim of this study is to present an pros and cons of educational infrastructure project in specific conditions of Kutno Forest District (Poland). This region has one of the lowest forest cover in Poland, what causes number of problems in proper creation of educational facilities, such as small area, where the trials could be drawn. The main assumption of planned nature infrastructure was an holistic approach to ecological and cultural issues. Project is composed of two didactic paths with marked stations, playground in forest arboretum and educational centre. To better understanding, the educational boards, using innovative teaching methods such as QR codes or interactive installations, will be erected. Moreover, polish original concept of permanent orienteering courses will be used, and game, based on augmented reality audio system, will be developed. Educational center will be located in old-fashion building of old granary. There will be an exhibition about forest and forestry, "Five Sense Forest Laboratory" - educational space coherent with Montressori education, and environmental observatory.

forest education, didactic paths, Kutno

Room "Colmar" (Novotel Freiburg)

IUFRO17-1546 **The De-Evolution of Forestry Education at Research Universities**

O'Hara, K.* (1); Redelsheimer, C. (2)

(1) University of California , Berkeley, CA, United States; (2) Society of American Foresters, Bethesda, MD, United States

Abstract: Forestry education is declining in size and influence at many research universities (those that grant Ph.D. degrees) around the world. This decline is the result of many factors. One factor is the dynamics of governance in research universities which is consolidating smaller academic units to create larger units. Forestry is often combined with programs in natural resources, biology, environmental science, or agriculture. Forestry has traditionally viewed itself as a profession with minimum professional thresholds for competency that are met by education standards. Forest scientists with applied backgrounds are also becoming an increasingly smaller proportion of these faculties. Non-forestry faculty in these units may not value the professional education or the need for minimal competencies. Whereas forests are no less important to society than in the past, the demand for foresters has not kept up with supply, thereby threatening these programs. The expansion of forestry education to non-research universities has contributed to a glut of foresters in some countries. The result is a decline in research universities offering forestry education. With forestry education increasingly moving toward non-research universities, there is a declining capability to produce applied scientists capable of moving forest science forward to address new and emerging challenges in forestry.

forestry education, research universities

Room "Colmar" (Novotel Freiburg)

IUFRO17-1525 **Adapting forestry education in New Zealand to a changing environment**

Manley, B.* (1)

(1) New Zealand School of Forestry, University of Canterbury, Christchurch, New Zealand

Abstract: The New Zealand School of Forestry at the University of Canterbury offers the only professional degree programmes in New Zealand. The Forestry Science programme commenced in 1970 while the Forest Engineering programme started in 1991. Although the focus of the degrees is on plantations, the aim to is to provide graduates with the skills and technical expertise to manage any forest for a full range of uses.

Key changes over the last 20 years to the operating environment for forestry education in New Zealand have been:
1. Increased ownership of forest land by indigenous Maori through Treaty settlement.
2. The focus of harvest shifting to the small-scale forest estate established in the 1990s.
3. Greater concern about occupational safety and health.
4. Enactment of an Emissions Trading Scheme
5. Availability of new remote sensing, harvesting, genomic and other technologies

This paper reviews the experience of the New Zealand School of Forestry in adapting to these changes. Responses have included curriculum development, changes to teaching practice, targeting field trips and case studies, and the initiation of underpinning research. Changes have been based on understanding the requirements and expectations of graduates in this changing environment.

Forestry education, professional forestry degree

Theme 1: Forests for People

Enhancing Forest Education through Regional Cooperation

Room "Colmar" (Novotel Freiburg)

IUFRO17-2000 **Forestry Education in Asia-Pacific Region: Challenges and Opportunities**

Innes, J.* (1); Zeng, M. (2); Wang, G. (1); Luo, X. (3)

(1) Asia Pacific Forestry Education Coordination Mechanism, UBC Faculty of Forestry, Vancouver, Canada; (2) UBC Faculty of Forestry, Asia Pacific Forestry Education Coordination Mechanism, Vancouver, Canada; (3) APFNet, Beijing, China

Abstract: In order to understand forestry education and its development in Asia Pacific regions, the Asia Pacific Forestry Education Coordination Mechanism (AP-FECM) has conducted a comprehensive survey on the current level of forestry related programs, capacity, issues, challenges, and development trends in the universities of the AP region. Over twenty key regional universities in forestry participated in this survey. The survey has also investigated several unique cases such as curriculum development, course articulation between universities in the region, international partnerships, transfer programs, and recommendations for future improvement. Being the first Forestry Education Research of its kind in the Asia Pacific region, this research will present the results of the survey, discuss difficulties and problems impacting higher forestry education in the region, identify gaps between international and domestic forestry education, determine priorities for teaching and learning, and explore potential web-based educational program to improve capacity building in sustainable forest management. The research will provide recommendations for AP-FECM to help tackle issues facing forestry education. We believe the results generated from this research, will be also helpful to the rest of the regions.

forest education e-learning challenge opportunity

Room "Colmar" (Novotel Freiburg)

IUFRO17-2635 **Student Mobility and Faculty Exchange Based on Joint Undergraduate Program of BFU and UBC**

Lin, Y.* (1)

(1) Beijing Forestry University, Beijing, China

Abstract: Based on the all-around partnership during the past years, Beijing Forestry University (BFU) and the University of British Columbia (UBC) have developed a system of diversified educational cooperation. One of the successful cooperative programs is the joint bachelor program (of forest science and wood science and technology) initiated in 2013. This 3+2 double-degree program is designed to provide BFU students with advanced knowledge, outstanding faculty and modern facilities to qualify them with bilingual and professional competence during the 3 years at BFU and 2 years at UBC. In addition to integrating quality educational resources from both sides, the program also gives strong momentum to the student and faculty exchanges of the two universities.

Inspired by this productive joint program, the presentation will focus on the program structure, administration mechanism, educational features and highlighted achievements of the program. Emphasis will also be given to how this program boosts the student mobility and faculty exchanges between BFU and UBC. Moreover, discussions will be launched on how to generalize similar programs in the Asia-Pacific region to strengthen the regional collaborations in forestry education.

Room "Colmar" (Novotel Freiburg)

IUFRO17-2911 **Facing the Challenge of Internationalization: UPLB's Initiatives in Forestry Education and Research**

Pulhin, J.* (1); Abasolo, W. (1)

(1) University of the Philippines Los Banos, College, Laguna, Philippines

Abstract: Internationalization in education, including the field of forestry, has recently emerged as a key challenge for most universities in quest for greater relevance in the context of changing time and societal demands. Like many forestry degree-granting institutions in Asia and the world, the University of the Philippines Los Ba ños College of Forestry and Natural Resources (UPLB-CFNR) embarked on internationalization as a strategic goal in forestry education and research. Three compelling reasons propelled such move: 1) to better respond to forestry-related local and national needs while contributing to global challenges like climate change and sustainable development goals; 2) to prepare for the thrust of ASEAN Economic Community where environmental protection and natural resource management is one of the key challenges; and 3) quest to perform better in the world university rankings. This paper presents the key initiatives in forestry education and research of UPLB-CFNR in response to the challenge of internationalization. Initiatives in forestry education includes curricular review and revisions, accreditation of forestry degree programs for quality assurance, and offering of international collaborative graduate program in Master of Science in Biodiversity and Conservation. Research initiatives include creation of interdisciplinary study centers and collaboration for inter/transdisciplinary and integrative studies with foreign universities. The paper concludes with key challenges confronting internationalization that may be applicable elsewhere.

Internationalization, forestry education, research

Theme 1: Forests for People

Enhancing Forest Education through Regional Cooperation

Room "Colmar" (Novotel Freiburg)

IUFRO17-3347 **Forestry education collaboration across national borders - opportunities and challenges**

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(1) University of Melbourne, School of Ecosystem and Forest Sciences, Creswick, Australia

Abstract: This presentation relates our experience in developing and teaching novel forestry education courses for international student audiences, and involving multiple universities in different countries of the Asia-Pacific region. The contrasting context for forestry education among different countries and regions of the Asia-Pacific enriches online teaching and learning and provides for animated communication between students. Students benefit from, and expect, experiential field-based learning to complement online materials. Elements of successful forestry education programs include research-led teaching and approaches that encourage collaboration among students in their learning. The universities and staff involved require long-term commitment and alignment of interests, while the journey to creating shared platforms and teaching programs is a learning experience for the staff as well as the students. Steps in developing cross national programs include mutual course recognition if dual degree and joint degree programs between universities are to prosper. We also discuss some of the problems and lessons learnt in working among institutions in different countries and the requirement for continuous updating and revising of shared curricula.

forestry education international online web

Room "Colmar" (Novotel Freiburg)

IUFRO17-2849 **International cooperation for tropical forestry education partnership towards 21st century**

Pipatwattanakul, D.* (1)

(1) Faculty of Forestry, Kasetsart university, Bangkok, Thailand

Abstract: The 20th century, tropical forest was depleted in the vast area leaving the situation that challenging us towards 21st century. Thailand in 1961, total forest area was about 53.3 % of the country, and 50 years later forest cover has declined to 33 percent. The main causes were high population growth, expansion of settlement, conversion forest land to farm land, and infrastructure development, resulting in more frequent and more severe problems of flooding, drought, and natural disasters. The situation related to depleted forest in the 20th century calls for paradigm shift in forestry education.
The Faculty of Forestry, Kasetsart University (KUFF)offers forestry education in all degree levels adjusted its curriculum to suit forestry situation and society needs during 1990s. Curriculum development was emphasized in forest policy, sustainable forest management, social forestry, urban forestry, climate change, plantation, biodiversity conservation. Research function was also reorganized with establishment of Thai Journal of Forestry. Specific training courses were organized with supports with Asian international agencies from Japan, Korea, China, and FAO-RAPA, RECOFTC, BIOTROP, SEARCA, CIFOR, ICRAF, WCS, and IUCN. Based on good platform of forestry education an international cooperation partnership will play important role in providing outside classroom experience. The 4 decades of successful academic cooperation between KUFF and University of Helsinki was the case study and to share the success in strengthen the forestry education with practical experiences, research performance that empowering students to be professional forestry. Anyhow, the ultimate goal of international cooperation partnership and together with formal education should create the education environment within the framework of 21st century learning and skills.

21st century skills, partnership, KUFF.

Room "Colmar" (Novotel Freiburg)

IUFRO17-2790 **Forest education of Kyoto University in collaboration with partner universities in ASEAN: Challenges for trans-disciplinarity and trans-border**

Kanzaki, M.* (1); Kitajima, K. (1)

(1) Division of Forest and Biomaterials Science, Graduate School of Agriculture, Kyoto, Japan

Abstract: The increasing importance of global issues related to forests, forest sectors need human-resources who can study and manage forest with wider scope. Trans- disciplinary approaches and trans-border scope are important to tackle with the current issues which related to forests. In Kyoto University, Division of Forest and Biomaterials Science, Graduate School of Agriculture has implemented several new courses and curriculum in collaboration with the other division of same schools and also with the other graduate schools in Kyoto University to strengthen the trans-disciplinarity of our education. On the other hand, we developed the summer school programs, international internship courses, and double-degree programs in collaborate with our partner universities of ASEAN and other region. In this presentation, we will report our challenges for trans-disciplinarity and trans-border in our forest education and the evaluation of these programs.

International collaboration, double-degree program

Theme 1: Forests for People

Enhancing Forest Education through Regional Cooperation

Room "Colmar" (Novotel Freiburg)

IUFRO17-2543 **Benefits of international collaboration for the New Zealand School of Forestry**

Manley, B.* (1)

(1) New Zealand School of Forestry, University of Canterbury, Christchurch, New Zealand

Abstract: The New Zealand School of Forestry at the University of Canterbury offers the only professional degree programmes in New Zealand. The lack of peers means that the School of Forestry has relied on international collaboration to ensure the quality and relevance of its programmes.

International collaboration has taken many forms including
1.Regular benchmarking of curriculum against those of comparable international forestry programmes.
2.Review of programmes by committees chaired by international academics.
3.Exchange programmes for undergraduate students.
4.Joint supervision of postgraduate students with off-shore universities.
5.Exchanges of academic staff.
6.Collaboration on joint research projects.

Fundamental to this collaboration has been the development of strong relationships between New Zealand forestry academics and their international counter-parts. This has facilitated an ongoing exchange of ideas and information and ensured that, although New Zealand is geographically isolated, New Zealand forestry education is not isolated and is informed by international best practice.

Forestry education, professional forestry degree

Room "Colmar" (Novotel Freiburg)

IUFRO17-3048 **Sustainable Management of Educational Forest Without Cutting Trees: A Case of Bogor Agricultural University, Indonesia**

Soekmadi, R.* (1)

(1) Faculty of Forestry, Bogor Agricultural University (IPB), Bogor, Indonesia

Abstract: Gunung Walat Educational Forest (GWEF) of 359 ha is located about 55 km at southern part of Bogor city, West Java, Indonesia. The forest was started to establish in 1963, when Faculty of Forestry was "separated" from University of Indonesia. Initially, the area was bare land and now is almost completely covered by tree species plantation (agathis, pine, rasamala, puspa, etc.). Main management policy is to develop a model of smallest sustainable FMU (Forest Management Unit) without cutting trees. The activity can be divided into two: (1) forest management, such as resin taping, tree planting, and marketing, and (2) facility management: lodging, facilitating student/researcher. Visitors come not only from Bogor, but also from other island in the country, and from overseas. GWEF generates income from resin product, lodging/service, and carbon trading. Starting from 2012, the management has been self-financing. However, now GWEF faces problems of forest regeneration due to government policy that does not allow cutting the tree within university forest.

university forest, self-financing.

Room "Colmar" (Novotel Freiburg)

IUFRO17-1673 **Sketching future forestry education for South East Asia: perspective Bangladesh**

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Abstract: British colonial approach is still in core of forest management of South East Asia (SEA). However, recent policies of management of forest are incorporating social aspects and considering diverse dimensions of human with various international commitments by conventions and treaties, lead the paradigm shift in forest management of SEA. This study examined century long forestry practices, forest policies, conventions and treaties on forestry, recent job markets, corporate mechanisms and blending knowledge protocols and found a demand existed to refurbish the current curricula of forestry education of SEA. Examining the forestry education of Bangladesh as case study focused from its inception to date particularly to expedite the demand of new arena of knowledge on science, social science, indigenous technologies to put forward the students with the current arena of world forestry science to meet the demand of the country. Moreover, knowledge on global change, biodiversity conservation, forest-people conflict management, landscape level restoration rather forest restoration, technological interventions in forest resource monitoring and assessment, invasive species management, carbon management and trading, panel wood and wood processing were found worth for sustainable forest management. Inclusion of stated new knowledge arena for forest science may facilitate readiness of future graduates for sustainable forest management.

Forest Management, Curriculum, Forest education

Theme 1: Forests for People

Enhancing Forest Education through Regional Cooperation

Room "Colmar" (Novotel Freiburg)

IUFRO17-2675 **Innovative Forestry Education**

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Abstract: Challenges such as climate change and deforestation have created high demand for sustainable forest management (SFM), and access to relevant education is important for improving forest management and helping to create a balance between environmental, economic, and social values in the Asia-Pacific (AP) Region. To improve capacity building of SFM, a joint educational program entitled Innovative Sustainable Forest Management Education in the Asia-Pacific Region has been established by a group of international renowned forestry universities including UBC, Beijing Forestry University, University of Melbourne, University Putra Malaysia, and University of the Philippines Los Baños. This program has developed a series of online courses by using an innovative pedagogical method to convey SFM knowledge. As the open educational resources, this program has attracted over 1000 interested learners including students, faculty members and professionals from the AP region. This study will present new technology, curriculum, pedagogy used in the course development, discuss strategies and methodology in creating courses, share lesson learned from the program development and introduce new initiative of new courses in tropical forest and potential SFM web-based program. We believe this study will provide useful experience and information to benefit forestry education worldwide.

SFM, forest education, e-learning, technology

Theme 1: Forests for People

49 - Impact of forestry research on policy, livelihoods and economic development in sub-Saharan Africa

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1909 **The Forestry Research Network for Sub-Saharan Africa at 16 : Opportunities and Challenges**

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Abstract: The Forestry Research Network for Sub-Saharan Africa (FORNESSA) was established in 2000 as an umbrella body for three sub-regional networks namely Association of Forestry Research in East Africa (AFREA), Southern Africa Development Cooperation- Food, Agriculture and Natural Resources (SADC-FANR) network and West and Central Africa Agricultural Research and Development (CORAF) network. The principal objective of FORNESSA is to foster regional cooperation, collaboration, coordination and integration of forestry research in order to contribute to conservation, sustainable management and utilisation of forest resources in sub-Saharan Africa. Over its short period of existence FORNESSA has made some inroads - contributed to the Global Forestry Information Service (GFIS), set up thematic working groups and produced state of the art book synthesis on critical issues relating to sustainable forest management and climate change. The network is constrained by lack of sufficient means to provide all the desired services to members. As the network grows time devoted voluntarily for coordination and for running the information service will become insufficient for its operations. So far IUFRO, FORIG and KEFRI have become the 'spark plugs' of the network. The success in future will depend on donor support as well as contributions from all member institutions.

forestry research, regional cooperation, Africa

K 5-7 (Konzerthaus Freiburg)

IUFRO17-437 **Public-Private Partnerships for sustainable agroforestry and business innovations in Africa: Allanblackia species as a case study**

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Abstract: Seed oil from multipurpose Allanblackia tree species, found in West, East and Central Africa, is the most economic important product of the species. Demand for seed oil (>100,000 tons/ year) exceeds supply from wild collection (210 tons/ year). This warrants the need for domestication and conservation of the species to ensure sustainable supply of seed oil. Public-Private Partnership (Novella Partnership) was established in 2002, to drive the domestication of the species in four pilot countries. Activities include community sensitization, genetic diversity analysis, conservation, participatory selection, development of propagation methods and agroforestry systems, supply chain and market development.

No variation was observed in fruit shape and seed yield among populations but fruit size, yield and shape varied significantly within populations of A. parviflora. Obovate fruit shape has more oil (53%) than the rest. Significant variation in oil content among trees was observed in A. parviflora and A. stuhlmannii as well as between pink and white flowered trees. Propagation methods {seed germination (75%), rooting of stem cuttings (82%), grafting (79.8%) and air layering (72%)} have been developed. Supply chain is established in Ghana, Nigeria and Tanzania. Income from 14 products made from Allanblackia floribunda in Cameroon, is $3,000 /year. In Tanzania, 3907 farmers have received Euro 600,000 from sale of 3,300 kg of Allanblackia nuts. Development of BECEL Gold from Allanblackia oil by Unilever and the short term income from Allanblackia products have inspired domestication of the species.

Allanblackia, propagation, cultivation, seed oil

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2073 **Potential contribution of bamboo based agroforestry to rural livelihoods in Omo Forest Reserve, Nigeria**

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Abstract: Forest degradation and deforestation have resulted in a short fall in timber supply from the forest. Thus, the scarcity of wood has highlighted the need to develop alternatives to meet demands for wood products. Bamboo is a viable substitute and could provide numerous benefits to the wood industry. Bamboo-based agroforestry has been suggested as a viable option for raising overall production as well as productivity of farming systems. Sadly, there is a low level of awareness about bamboo agroforestry among rural farmers in Nigeria and this has resulted in indiscriminate cutting and burning which makes their clumps and bamboo plantation unproductive. We evaluated the level of awareness among local farmers on bamboo agroforestry in Omo forest reserve, Nigeria. In the field survey, questionnaires were administered to 70 farmers resident in four communities in the reserve. Data were collected through interviews and personal discussions. The qualitative data were analysed using descriptive and inferential statistics. Most of the farmers (80%) were male with a large proportion of farmers being married (78.6%). They were mostly literate and had acquired formal education. The mean household size was 5 persons. Land ownership was a challenge with many obtaining permission to use government owned land. Financing their farming activities was mainly through personal savings (74.3%), while 65.7% used their house hold for labour during farming activities. Approximately, 66% were willing to adopt the practice if well enlightened, with 47.1% willing to practice on a large scale. Bamboo production was a source of income and improved the livelihood of members of the rural communities, helping to meet pressing needs such as furniture, payment of school fees, construction and aerial poles. The development of bamboo-based agroforestry through the help of government, NGOs, and donor agencies would improve rural income, while reducing the pressure on existing timber resources.

rural income, bamboo, substitute wood

Theme 1: Forests for People

49 - Impact of forestry research on policy, livelihoods and economic development in sub-Saharan Africa

K 5-7 (Konzerthaus Freiburg)

IUFRO17-3978 **Designing a PES strategy for Transboundary riverine Forest Ecosystem: The case of River Lumi Taita Tavetta county Kenya**

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Abstract: River Lumi originates in Tanzania on the slopes of Mount Kilimanjaro and stretches a distance of 50 kilometres in Kenya before emptying its water into the Indian Ocean through Tanga, Tanzania where it provides hydro power. The river supports farming activities along the Kenyan side and contributes to approximately 90% of food supplies along the Kenyan Coast. The riverine ecosystem is under serious degradation. A survey was undertaken to develop a rehabilitation strategy for River Lumi catchment and a national Payment for Ecosystem Services (PES) scheme for trans boundary resources in Kenya. Baseline socio-economic, ecological and hydrological surveys were conducted along the catchment area and a rehabilitation framework developed. Stakeholder consultations were held, household questionnaires administered and representative sample plots established to collect the ecological data. The main driver of degradation was over abstraction of water for crop irrigation. The river support livelihoods of thousands of people living in both Kenya and Tanzania but is threatened by unsustainable human activities. Payment for Ecosystem Services shall ensure that land users are compensated for the environmental services they generate, hence providing a direct incentive for them to make land use decisions that are ecologically sound and that contribute to riverine conservation.

Transboundary, Livelihood, PES, rehabilitation

K 5-7 (Konzerthaus Freiburg)

IUFRO17-255 **The Impacts of Participatory Forest Management Implementation on the Community Livelihoods around Eburu forest, Kenya**

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Abstract: Participatory Forest Management (PFM) is a management tool that involves mobilizing of local persons for group action in managing specific forest area adjacent to their settlement in order to ensure socio-economic development of community and reduce pressure on forests. This involves sharing responsibilities and benefits according to a well-defined and mutually agreed on set of rules and regulations.
This study examines the impact of Participatory Forest Management (PFM) on the livelihoods of people around Eburu Forest taking part in PFM with the main objective of contributing to improved forest governance. It studies the impacts on the livelihoods of the Committee Forest Association (CFA) members before and after the introduction of this forest management tool. The study questions: has Participatory Forest Management led to marked economic, social and environmental impacts? ; And what are the perceptions of the community on participatory forest management. The hypothesis tested was: Participatory Forest Management has led to improved livelihoods of the people practicing PFM around Eburu Forest.
In March 2015 data was collected on effects on the livelihoods of people showing the social, natural and financial capital gained from the forest since the beginning of PFM. The perceptions of the people on PFM were also assessed. Challenges that the people face were assessed with not having a policy that states how the benefits should be shared between the community members and the Kenya Forest Service being the most challenging.
The results show dependence on Eburu Forest and the forest benefits exceed the cost. It also shows increased food security as the people practice agroforestry more compared to previous years. The study therefore concludes that though expensive and gradual PFM is a forest management tool that can help support the people around Eburu forest by improving their livelihoods, ensuring food security and also improving forest governance.

Participatory Forest Management, Livelihoods

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1469 **Ghana's high forests: trends, scenarios and pathways for future developments**

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Abstract: Reducing tropical deforestation and forest degradation is of global importance for the sustainable production of timber and non-timber forest products, the mitigation of climate change, and the conservation of biodiversity. In Ghana, the continuous decline of forest resources and the high demand for timber have raised stakeholders concerns about the future timber production prospects in the country. This study assesses current resource availability situation and explore the consequences of different scenarios for future timber resource developments in Ghana. Data was collected using interdisciplinary research methods, both qualitative and quantitative, including semi-structured interviews, bio-physical assessments, and scenario planning. The results indicate that forest governance and resource demand are the key driving forces affecting future of timber resources. In recent decades, increasing gap between timber demand and supply drives illegal logging. Existing forest development trends are either too small-scale or too ineffective to drive forest recovery. Four scenarios were developed: legal forestry with emphasis on improving the resource base to meet high demand; forest degradation, a business-as-usual scenario; forest transition, with emphasis on expanding the resource base in response to environmental concerns; and timber substitution focusing on wood substitutes. The study concludes that current plantation establishment efforts are not sufficient to bridge the gap between timber demand and supply, partly due to low establishment rates and lack of appropriate management of newly established plantations. For future developments, policy and management options should target measures that reduce forest degradation, increase area and productivity of commercial forest plantations, and encourage integration of trees into farming systems.

Ghana, forest degradation, governance, timber

Theme 1: Forests for People

49 - Impact of forestry research on policy, livelihoods and economic development in sub-Saharan Africa

K 5-7 (Konzerthaus Freiburg)

IUFRO17-650 **A South African Integrated Forest Protection Strategy**

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Abstract: The South African forest sector provides valuable renewable natural resources, sustaining industries and conserving biological diversity, while contributing significantly to national and provincial economies and employment. This is off a static resource base which is exposed to extensive damage from pests and diseases, fire and other causes, such as climate change, damage-causing animals, invasive plants, illegal logging, and illegal trade in forest products. Evidence suggests that these risks will continue to escalate in the future. Solutions are multifaceted and complex, involving participation of national and local government, government agencies, local communities, and the private sector. This paper talks to the development of a National Forest Protection Strategy through a public-private partnership with the South African Department of Agriculture, Forestry and Fisheries. Relevant case studies highlight needs, as well as subsequent interventions and implementation. The methodology used involved developing a basic framework identifying goals, principles and strategic actions, and an implementation plan. Wide stakeholder consultation took place, with two specialist task teams providing technical inputs. Implementation of the strategy through a strategic, co-ordinated and multidisciplinary approach will enhance the efficiency and effectiveness of forest protection in South Africa, such that risks can be addressed, and that the public and private sectors can fulfill their roles in terms of sustainable forest management.

fire, pests, diseases, public-private partnership

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2787 **Utility of a typology of timber artisanal loggers, in order to contribute to the formulation of public policy on logging in Orientale province**

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Abstract: This paper discusses the types of wood artisanal loggers, in order to assist in the formulation of public policy on logging in Orientale province (DRC).
The objective was to characterize artisanal timber in order to propose the establishment of legal channels to
increase the contribution of this product to the national economy.
Surveys were conducted with 412 artisanal loggers active in 23 villages in Orientale province between 2010 and 2012.
Factor analyses for mixed data (FAMD) and hierarchical classification on principal components (HCPC) were performed.
Three types of artisanal loggers were distinguished: (1) sawyers of provincial origin who supply local markets in
Kinshasa; (2) sawyers of local origin that serve local markets; (3) sawyers from the other provinces of Orientale province,supplying markets in Kivu and Uganda.
Taking into account the specificity of each of these groups of artisanal operators could improve the development and implementation of public policy measures needed to secure and formalize logging activity.

Economic policies, commodity markets, logging, DRC

Theme 1: Forests for People

54 - Global Forest Technology Sharing Framework

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1548 **Building the Open Forestry Framework to Connect and Curate Forestry Knowledge**

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Abstract: How do we effectively connect people, technology, problems and solutions in an intuitive framework? The mechanism to tackle these problems concurrently and at the scale needed for success does not exist. Today, vast forestry knowledge and data are used by a relatively small number of people who have expertise in disciplines ranging from silviculture to systems biology. Other people that could contribute to and benefit from the pool of knowledge have limited ability to know what information exists, and where to find it. Broader knowledge transfer is crucial to solving the world's forestry related problems on multiple scales for the betterment of society and the environment.

We are building an Open Forestry movement where anyone can access forestry knowledge and to improve the vitality of forests for the betterment of society and the environment.

I will discuss the technical aspects of how we are meeting these challenges by linking people through digital and human networks to curate open forestry knowledge and make it available to anyone, anywhere.

Open Forestry brings information to people in distant places. It allows people to engage in dialogue and projects from around the world with the communication tools they are already comfortable using.

Open, Forestry, Curated, Knowledge, Movement

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-537 **Open Forestry, a new generations movement**

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Abstract: There is a connecting thread going through Araucan ía, Paysandú, Acre, Kwazulu-Natal, Savannakhet, Zhejiang, and it relates to people - how people use land, plan for their families and future generations, while aiming for a decent life.
The New Generation Plantations platform (NGP) has been there - we have travelled through all these regions. And what we saw is a cascade of degraded landscapes where courageous women and men fight and take risks everyday, looking for different models, seeking long term solutions.
NGP brings together people from different backgrounds, with different interests, to share their knowledge, experience and views, to listen, and to reflect on and question their own attitudes and actions. Only when you listen to and learn from those who think differently from you, can you evolve your knowledge and understanding.
The Open Forestry movement connects people who live on the land, from the land, and for the land, and who seek different models and new long term solutions. Connecting people with forestry knowledge, empowers them to restore their land, restoring their hope of better living conditions.

Open, Forestry, Social Movement, New Generations

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2125 **An Open Science view of a technology sharing framework**

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Abstract: "Open Science" has already become a common label for types of work that embrace transparency and sharing. There are as well additional features underlying the concept and conduct of open science that may not be immediately apparent but are important for achieving both research and societal goals, broadly defined.

I will present a policy view of open science systems, focusing especially on the values of transparency, resource sharing, and information amplification that are particularly well-articulated, if not always fully executed, by communities embedding the principles of open science in their work. I will discuss the policy gaps that may prevent the achievement of truly open information production and sharing. In particular I will consider the aspect of open science that is focused on the inclusion of users of research outputs and applications in the initiation of projects and in the iterative improvement and promulgation of the final concepts or applications.

I will include a specific consideration of the Global Forest Technology Sharing Framework and will discuss how sets of values from open science framing may be useful in the further development of the framework, and of these types of platforms generally.

Open science, transparency, resource sharing

Theme 1: Forests for People

54 - Global Forest Technology Sharing Framework

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2384 **Sustainable Intensification and Restoration: How to use technology to meet tomorrows demand and increase low-cost restoration of degraded land**

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(1) Suzano Pulp and Paper, Environmental Manager, Sao Paulo, Brazil; (2) WWF-Brazil, Sao Paulo, Brazil

Abstract: The world is under a major challenge. Conservation and restoration efforts committed by countries through international agreements aims to restore 150 Mha , which will require, under current practices, billions of dollars and an unprecedented quantity of skilled workforce.

At same time, by 2050, the world will need 3 times more wood. So, how can we meet tomorrow's demands without destruction of natural Forests, but instead enhancing them?

In Brazil, Suzano Pulp & Paper and WWF-Brazil are working to address this challenge, designing systems to restore forests in a more efficient and less costly manner.

The challenge is divided in two components : "Sustainable Intensification" and "Conservation & Restoration". Suzano and WWF are working to:

i) Answer how we can meet future demand for wood with fewer resources. Concepts like precision silviculture, climate based planning and biotechnology are under review and will reveal important production opportunities for today and tomorrow. We will explore the results so far and pointing collaborative approaches to overcome barriers to a better and sustainable supply.

ii) Restore thousands of hectares in the next decades, using low-cost and better restoration techniques to foster an important concept: 'restoration for all'.

Current techniques prevent medium and small producers to commit to restoration due to high cost and specific skills demanded. One of these tools uses low-resolution satellite image to assess current vegetation status (degraded, primary, secondary or climax) to refine the best restoration strategy. The first 4,000 hectares trial in S ão Paulo showed that is possible to reduce the restoration cost by 70%.

The next phase will combine priority areas for conservation with restoration costs aiming to reach the best cost-benefit possible.

These Technologies, and knowledge generated by this effort, will be shared through Open Forestry to reach as many forest producers and other engaged stakeholders as possible.

Restoration, Intensification

Theme 1: Forests for People

25 - Food-trees in forest and farmlands: improving livelihood of communities in tropical regions

K9 (Konzerthaus Freiburg)

IUFRO17-1947 **Safe guarding the forest food tree diversity**

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Abstract: Tropics are endowed with a diversity of indigenous food tree (FT) species rich in various vitamins and minerals, important in fighting hidden hunger, a common problem in developing world where there is over-reliance on staple food diets. A significant percentage of these fruit species remain undomesticated and are still harvested from the wild. Few have been selected and bred according market preferences. FT diversity in wild is threatened by deforestation, degradation and destruction of natural habitats, including clearing for urban centres, settlement and farming, logging, forest fires, overexploitation and unsustainable harvest, natural disasters, climate change. Domesticated FTs are mainly selected and improved for the desired traits via clonal propagation and this threatens intraspecies diversity. As these FT species genepool in virgin forest continue to be depleted, important genotypes for combating the effects of climate change, new diseases and pests, are lost. It is therefore important to ensure that these food tree diversity is secured for current and future uses. Ex situ conservation offers the best option. However, tree species conservation differ from annual crop species, and therefore the standard model used for the management and ex situ conservation of annual crops only partially apply. The large number genera and intra-species diversity, their long generation intervals, large growth forms, generally outbreeding reproductive systems and species-specific regeneration requirements need a complex and flexible system for the management and conservation of tree genetic resources. These paper explore the challenges encountered in conservation of food trees' diversity and possible are approaches to safe-guard it.

conservation, diversity, food trees

K9 (Konzerthaus Freiburg)

IUFRO17-67 **The contribution of trees and palms to a balanced diet in three rural villages of the Fatick Province, Senegal**

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Abstract: Improving the quality of people's diets represents a major challenge for developing countries, particularly in Sahelian African countries. Foods from trees, shrubs, and palms are present in many meals and may improve dietary quality, especially for rural communities but, as their contributions have rarely been quantified, investigating the link between the intake of tree foods and the nutritional composition of diet is important. This study assesses the contribution of tree and palm foods to dietary intake in three rural communities in Senegal, using three household food consumption surveys to quantify the dietary intake of meals. The consumption of tree and palm foods in meals was frequent, mentioned by 93-99% of the families depending on the time of year. Products of 11 tree and palm species were used in meals, with Adansonia digitata (baobab) leaves the most frequently mentioned. The energy contribution of tree and palm foods was low, but their contribution of certain micronutrients was high, with 56% of the daily household food consumption of vitamin A, 45% of vitamin C, 17% of vitamin B6 and 21% of iron (Fe). Products from 18 tree and palm species were consumed as snacks or beverages between meals, and consumption was frequent in February and June, but rare in October. We discuss the possibilities of improving nutrition in rural communities from an increased use of trees and palms.

agroforestry; vitamins; minerals; nutrition

K9 (Konzerthaus Freiburg)

IUFRO17-3854 **Economic and ecological benefits of forest landscape restoration in food production systems at global and local level**

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Abstract: Unsustainable food production systems and their related land use practices are leading causes of global land degradation and deforestation. Productive landscapes are crucial to feed a growing population and provide essential ecosystem services. Nature-based solutions, such as forest landscape restoration (FLR), allow us to increase food production and improve livelihoods while conserving ecosystems. This session will demonstrate our approach to FLR, showcase best examples and relevant tools. The following will be addressed:
-There is a rich body of literature on the socio-economic drivers of degradation and the costs and benefits of avoiding it. Less studied is the impact of restoration on global food security. We will provide field examples of how degraded landscapes can be transformed into productive ones and the impact on crops and agricultural commodities.
-Specific interventions, such as Farmer Managed Natural Regeneration (FMNR) and conservation agriculture that have been tested in Malawi.
-Case studies highlighting the economic benefits of growing cocoa under agroforestry systems (AFS), the positive impacts on community resilience and how AFS can be employed by the private sector to address deforestation.
-Brazil's efforts to integrate FLR and food security into broader, cross sectoral policies.

Agroforestry, food security, forests, restoration

Theme 1: Forests for People

25 - Food-trees in forest and farmlands: improving livelihood of communities in tropical regions

K9 (Konzerthaus Freiburg)

IUFRO17-3784 **Intergrated assesment of baobab value chain in semi-arid areas of Dodoma, Tanzania**

Swamila, M.* (1); Kimaro, A. (1); Sieber, S. (2); Graef, F. (2); Uckert, G. (2); Yamlinga, B. (3); Mwinuka, L. (4)

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Abstract: Indigenous fruit trees and nuts such as baobab represent potential safety nets in terms of fruits, food and herbal medicine and are important contributor to improved livelihoods in semiarids due to their potential to offset famine by providing food in terms of fruits and fruit pulp. In this study we assessed the roles of baobab in improving nutrition, income, food security and human health, gender roles and dynamics and constraints to the development of baobab value chain. A socio-economic survey was carried out in Kongwa and Mpwapwa districts in line with the study ojectives. It was revealed that, baobab is the third contributor to the rural household income after farming and off farm employment. This study revealed important roles of baobab in rural household stratergies for (a) food including traditional recipes such as in preparation of porridge and its use in beverages, leafy vegetables and (b) health and medicinal roles. It was reported that 38.6% of respondents uses baobab products in treating stomach diseases such as diarrhoea. Results revealed more females (61.6 %) than males (38.4%) being involved in baobab collection activities. There were observed variations in baobab value chain with more women than men participating in picking, collection and processing activities. There were markedly variable roles between gender in processing with women being involved in small-scale processing of the fruit into beverages and snacks compared to men whom were being involved in high skilled processing products .The noted increasing trend on intensified economic activities in the Baobab value chain clearly shows importance of the tree resource in the ecosystem as well as on improved livelihood. However, there is a need to enhance capacity among stakeholders as related to collection, processing, quality control, and packaging, promotion of markets and marketing strategies,and machinery fabrication.

Livelihood, roles of baobab; gender

K9 (Konzerthaus Freiburg)

IUFRO17-2789 **An Assessment of Community-Based Biodiversity Conservation and Rural Livelihood Improvement in the Buffer Zone of Bardia National Park, Nepal**

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(1) Tribhuvan University, Institute of forestry(IOF), Kathmandu, Nepal

Abstract: Community-based biodiversity conservations are bottom-up activities that bring individuals and organizations together to work towards achieving desired environmental goals. This study was carried out in five Buffer Zone Community Forests (BZCFs) of Bardia and Banke districts. The main thrust of the study was to assess the impacts of buffer zone Program in the socio-economic indicators of the local communities (women, poor and disadvantaged groups (DAGs) and biophysical indicators of the buffer zone forest. Various tools of PRA including semi-structured questionnaire, focus group discussions were applied to collect the data. Simple qualitative method was used for data analysis. Five BZCFs were selected in such a way that three from Bardia district and two from Banke district according to the criteria fixed by the park staff, local people and several line agencies. Almost all the users have the positive responses toward the BZCF Program. Skill, attitude and behaviour of the users have positively improved after the formation of BZCF. Out of the five BZCFs, Rammapur BZCF was found more decision power, effective fund rising mechanism and poverty focus programs rather than four. Index of Relative Ranking (IRR) and Index of Perceived Analysis (IPA) was used to check the people perception toward BZCF. Index of Relative Ranking (IRR) was received the maximum value 0.9 on biodiversity conservation activities. It is the indication of increasing awareness level on biodiversity. Free distribution of benefits among the poorest, encouraging the income generating activities and fair and equitable benefit sharing should be implemented for the better mechanism of reducing the poorest of the poor people in an area. The management system of BZCF should be further boosted by providing economic, institutional and moral supports by the park and donor agencies so as to develop the well institutionalized local stewardship in conservation.

K9 (Konzerthaus Freiburg)

IUFRO17-914 **Forest gardens improve food security and resilience**

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Abstract: Recent trends indicate that forest gardens or tree-dominated landholdings in Sri Lanka are being converted to short-term (annual or semi perennial) cash crops that can generate large and quick returns. However, long-term (trees and shrubs) crops could provide resilience to stressors and greater food security than short-term crops. To test this, we quantified profit generated from short and long-term crops and their nutritive values in 85 landholdings at 9 locations in the Intermediate agroecological zone. High crop diversity and the mixture of long and short-term crops in these landholdings conferred livelihood stability in terms of profit and nutrition from food crops. Of the 165 food crops, 19% were carbohydrates, 6% proteins, 3% fat and 72% micronutrients. Tree crops dominated landholdings and were harvested every year for several years. These generated greater profit, were more drought tolerant, less susceptible to animal pests, and richer in nutritive values. Since short-term crops included green leafy vegetables and staples (rice), farmers also chose to cultivate short and long term crops for daily and future use. The tree dominant agricultural model offers livelihood stability, food security, mitigates micro nutrient deficiency (hidden hunger) and resilience to rainfall variability and animal stressors.

Forest gardens Sri Lanka Food security Resilience

Theme 1: Forests for People

20 - Open Session

K9 (Konzerthaus Freiburg)

IUFRO17-3542 **Public acceptability of value-based forest management scenarios**

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Abstract: Forest management is contested, and managers are challenged to incorporate the multiple ways forests are valued in society. A number of international policy approaches seek to integrate two or more values, but the extent to which they produce outcomes acceptable to the public is not well understood. In this research we explored public acceptability of three forest management scenarios developed by staff of government agencies to incorporate competing values in different ways. Information about the scenarios, including modelled outcomes, was presented to members of the public in a mail survey of 915 participants. A scenario emphasising values relating to Visitor Enjoyment was rated the most acceptable, with a scenario seeking to balance Habitat and Timber slightly less acceptable. Least acceptable was a scenario focused on reducing Bushfire Risk, which included clear-fell logging. Consistent with previous studies, the type and location of timber harvesting appeared to have a strong influence on public acceptability of forest management. The two more acceptable scenarios involved careful planning of the type and location of harvesting to fit with other values (habitat in one scenario, visitor experience in the other). This careful integration of values in the landscape was absent from the least acceptable scenario.

Values; Social acceptability; Forests

K9 (Konzerthaus Freiburg)

IUFRO17-3183 **Ethnographic Analysis of Participatory Forest Management: the role of state in mangrove management in Kenya and Zanzibar (Tanzania)**

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Abstract: Post independence African governments maintained institutionalization of command and control policies and legislations to govern tenure - ownership, access, exploitation and use rights up until early 1990s, when there were widespread realization that state mechanisms were weak to manage persistent overexploitation, degradation and loss of forest resources. Participatory Forest Management (PFM) was promoted and quickly gained widespread recognition as an inclusive policy strategy for state institutions to engage communities in collaborative management approaches for sustainable utilization and conservation. With over two decades of testing and practicing PFM for different forest types, controversies on the strengths and challenges of this policy strategy are evident. Unlike the counterpart terrestrial forests, unique ecological complexities of mangrove forests at the land-sea interface that require multi sectoral approaches pose challenges in practicing PFM. We use ethnographic approach to analyse and compare the role of multi sectoral complexity of state institutions in Kenya and Zanzibar (Tanzania) in shaping PFM for mangrove management. We reiterate the complex forestry-fisheries mangrove ecological system and how it complicates the state institutional control, coordination, integration and community engagement. We further demonstrate the necessary adjustments of the PFM basic approaches for sustainable mangrove resources conservation and management.

community participation, governance, mangroves

K9 (Konzerthaus Freiburg)

IUFRO17-624 **Placing community-based multiple-use forest management at the centre of the forest policy agenda**

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Abstract: Brazilian forestry law recognizes forests as public heritage for all citizens, and further recognizes their role in promoting social welfare for rural communities, which use and have domain of over 50% of Amazon public forests. However, there is a clear lack of public policies to support this notion. As such, a key issue for the community forestry sector is the need to focus on integration of traditional and technical knowledge and the promotion of institutional and local capacity of communities to manage these forests, and as such maintain in the long-term their economic and environmental goods and services.
Rural education and training has a central role in the formation of a new generation of forest producers with management skills, though the response in terms of empowerment is slow, requiring at least a decade of investments. In the short-term, a transitional model is required to promote new arrangements in the relation between communities and businesses. With the government and civil society assuming a mediator role in the process to ensure a better balance between the private enterprise objective of maximizing profits, and the socio-environmental objectives of assuring participation of the local people in revenue distribution, and of minimizing impacts on biodiversity. Shared management is a crucial aspect for both the forest concession model, and for scaling up community forestry.
Integration of forests into a new paradigm of economic development and social inclusion through their multiple use should consider the value of products and ecosystem services. Achieving this goal will depend on the capacity to promote local governance, negotiate the expansion of educational and infrastructure policies in the rural environment, and ensure the presence of technical assistance in the field. Finally, comes the need to foster responsible markets and consumers, linking forest products, environmental services and poverty alleviation in the tropical region.

community forestry;rural development; Amazon

Theme 1: Forests for People

126 - Restoration of degraded forest landscape through alien species for livelihood improvement in tropics

K9 (Konzerthaus Freiburg)

IUFRO17-90 **Basic research for future eventual Forest Landscape Restoration (FLR) of sandstone plateaus of Voltaian geological unit in West-Africa**

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Abstract: The plant diversity inventory coupled to spatial land assessment were used to evaluate the growth of plant species used during several reforestation processes and to determine the plant resources adapted to restore sandstones drought ecological zone in north of Togo. The research consists of an assessment of pilot sites previously reforested with exotic species follows by the land use pattern classification through Landsat LOI8 image classification. Finally, a forestry inventory of ecosystems pattern was done. A total of 75 forest samples were installed. 36 plant woody species belonging to 31 genera and 19 families were recorded after sampling. Trees structure average parameters are 8.61 ±0.57 m, 11.28±1.76 cm, and 0.018±0.009 m2/ha, respectively for height, diameter, and basal area. The overall accuracy and the kappa statistic of the classified map were 82.5% and 0.77, respectively. Shrubby savannah, croplands/fallows, and croplands represent 95% of land features. The landscape is dominated by species with high tolerance in term of water used. 88.88% and 83.33% of the batch of tree species are potentially quoted respectively for medicine and wood fuel use. Explore the biology, the regeneration and the vegetative multiplication of the native species, would be useful for any eventual afforestation program in this landscape.

biodiversity, drought, degradation, ecology, Togo

K9 (Konzerthaus Freiburg)

IUFRO17-2826 **Highland restoration to maintain ecological services of forest degraded landscape in northern Thailand through the King Bhumibol's initiatives**

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Abstract: The Royal Agricultural Angkhang Station, Chiang Mai, is the first royal project initiated by the King Bhumibol since 1969 to solve the problems of deforestation, poverty and opium production by promoting alternative crops, thereby improving livelihood of hill tribes. The highland reforestation was later begun in 1982 and has continued to cover the area about 130 ha with four planting schemes: exotic monoculture, exotic mixed stand, exotic and native mixed stand so-called the Village Forest Project (VFP) and bamboo planting. In early 2016, the 20x20 m sampling plots for monoculture and 40x40 m sampling plots for mixed stands were under taken to represent key tree species and ages and planting area, totaling 64 plots. Tree growth, biomass and the carbon stored, soil carbon accumulation were analyzed as well as environmental, social and economic co-benefits.

Regardless of planting of exotic tree species, native tree species belonging to 31 families were observed indicating natural regeneration potential in this highland reforestation. The total plantation area of 118 ha (excluding bamboo planting) can sequester the total of 93,666 t CO2, accounting for 56 and 44% in biomass and soil respectively. The exotic monoculture stand had the greatest CO2 storage in biomass, the VFP had the highest carbon accumulation in soil and the exotic mixed stand had the greatest overall carbon sequestration potential. However, the VFP, initially implemented to solve the problem of fuelwood shortage of the hill tribes in the area, could better provide environmental, social and economic co-benefits compared to the others: conservation of biodiversity, natural regeneration of native species and improving livelihoods of the hill tribes. However, implementation at landscape level through land-use zoning and application of appropriate planting scheme in each zone is recommended as best practice for the highland reforestation for greenhouse gas mitigation and community sustainability.

restoration, highland, carbon, king's initiatives

Theme 2: Forests and Climate Change

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KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1158 **Dynamics of epigenetic and genetic variation within and between populations and generations in two conifers and two angiosperms**

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Abstract: While recent landscape genomic investigations have identified genetic variation that affects local adaptation, a considerable part of additional phenotypic variation is still not explained. Recent studies suggest a prominent role of epigenetic variation to this effect. Intra- and interpopulation, as well as transgenerational, patterns of epigenetic versus genetic diversity, is reported. Epigenetic variation (differential DNA methylation evaluated by the MSAP technique) was studied in peripheral populations of conifers (Pinus nigra, Cupressus sempervirens) and angiosperms (Prunus avium, Platanus orientalis). Genetic variation in the same individuals was investigated using SSR, ISSR and AFLP markers. Most of the epigenetic and genetic variation resided within populations, however partitioning contrasted between the two variation types. Levels of epigenetic and genetic diversity did not differ significantly in most comparisons and were not significantly correlated, but genetic diversity values were usually higher. Evidence for transgenerational environmental influence on the epigenome (low faithful Mendelian inheritance) was also found. Overall, epigenetic variation appears not to be congruent to genetic variation and epigenetic variation seems uncoupled from genetic variation. Nevertheless, epigenetic analysis offers further insights in understanding the basis of local adaptation, the role of the epigenome in evolvability as a climatic change response, and in advancing gene conservation/genetic monitoring.

epigenetic variation/inheritance, genetic markers

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-569 **Morphometric and molecular variability among Julans regia populations**

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Abstract: European walnut (*Juglans regia*) is an economically important species used in the warm temperate and sub-tropical zones of the Northern Hemisphere for fruit and wood production. Besides the natural influence of climatic and geomorphological barriers humans have affected ist gene pool. We studied mainly natural walnut populations across the Eurasian continent on a morphometric (23 populations, 1391 ripe nuts) and molecular level (44 populations, 581 trees). By using seven microsatellite loci the population genetic diversity and differentiation were assessed. Nut shape (roundness index) and nut density were used as morphometric traits to evaluate quantitative variation at the population level. Highest allelic richness after rarefaction amounted to 7.05 in a Pakistani populations whilst the lowest value of 3.04 was found in a Kyrgyz population. The genetic differentiation among populations was high (F_{ST} = 0.217; R_{ST}= 0.530) indicating a strong phylogeographic pattern. Approximated Q_{ST} based on nut roundness equalled F_{ST}, however, respective value for nut density considerably exceeded F_{ST} indicating selection. Nut density was moderately correlated with altitude, latitude and longitude, and differentiated populations according to their origin. Pakistani and Indian populations showed highest nut density. These South Asian populations contain putatively ancestral nut forms, which probable have been lost in other populations as a consequence of human selection.

microsatellites, nut traits, QST, FST

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3119 **Morpho-genetic differentiation of close timber Guibourtia species newly listed on Appendix II of CITES**

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Abstract: For conservation issues, confounding species in particular those that are economically important can be detrimental. Nowadays, molecular genetics has revolutionized many fields in ecology and in the last few decades, Next Generation Sequencing (NGS) and its applications in phylogeny has become essential in complex species delineation. In this study, using whole plastid genome sequencing and phylogeography approaches combined to morphological studies, we focus on the three highly related timber species (Guibourtia. tessmannii, G. pellegriniana and G. demeusei, Fabaceae, Caesalpinioideae). These three species are exploited under the same trade name (bubinga) and have high commercial value (wood among the most expensive in the world). They are under significant threat due to illegal logging and have been recently listed on appendix II of CITES. We aim to answer following questions: (i) are the three species closely related from the genetic point of view? And (ii) is it possible to identify morphological traits that could help forest institutions to differentiate these species in order to implement both effective conservation actions and sustainable management of the remaining populations?

Fabaceae,Caesalpinioideae,conservation,genetics

Theme 2: Forests and Climate Change

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IUFRO17-2833 **Toward gene conservation triage: A United States national prioritization of tree species threatened by climate change**

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Abstract: Climate change is a critical threat that will increase the likelihood that forest tree species could experience population-level extirpation or species-level extinction. Scientists and managers from across the United States Forest Service have cooperated to develop a framework for conservation priority-setting assessments of forest tree species. This framework uses trait data and predictions of expected climate change pressure to categorize and prioritize 339 native tree species for conservation, monitoring, management and restoration across all forested lands in the contiguous United States and Alaska. The framework allows for the quantitative grouping of species into vulnerability classes that may require different management and conservation strategies for maintaining the adaptive genetic variation of the species within each group. This categorization is based on risk factors relating to the species' (1) exposure to climate change, (2) sensitivity to climate change, and (3) capacity to adapt to climate change. We used K-means clustering to group species into seven classes based on these three vulnerability dimensions. The most vulnerable class encompassed 40 species with high scores for all three vulnerability dimensions; these will require the most immediate conservation intervention. A group of 46 species had high exposure and sensitivity, probably requiring conservation assistance, while a group of 72 species had high exposure and low adaptive capacity, probably needing close monitoring. This assessment tool should be valuable for scientists and managers determining which species and populations to target for monitoring efforts and for pro-active gene conservation and management activities.

gene conservation; vulnerability; climate change

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-2389 **Gene conservation of Sorbus torminalis L.: deep insights into genetic patterns of a rare tree species in Southern Germany**

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Abstract: Sorbus torminalis is a rare forest tree species in Central Europe, with increasing importance under climate change, due to its drought resistance and high quality timber. To date no regulations for conservation of local gene resources or for production and trade of forest reproductive material (FRM) exist for this species. Currently, it can be harvested, traded, raised and planted in forests across distant regions and country borders. Therefore strategies for gene conservation are necessary to be elaborated based on detailed knowledge of the local gene pool. Hence a genetic screening, based on eight highly variable microsatellite loci, was performed to assess the regional genetic structure of S. torminalis in 28 populations in Southern Germany. Phenotypic assessment, genetic diversity indices, and clonal structure assessment assisted in selecting suitable seed harvesting stands. Furthermore plus trees selected for their promising genotype and phenotype will be identified to provide a broad genetic basis for seed production in the future.

genetic diversity, conservation, wild service tree

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-2148 **The reactions of Scots pine trees from different genetic groups comprising the population to the effect of meteorology and air pollutants at different stages of their development**

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Abstract: Genetic diversity of tree populations is a key factor of their sustainability. The knowledge gaps are mainly related to differences in reactions of trees from different genetic groups to environmental stress. Therefore in the present study we attempted to detect variation in tree reaction from the genetic group characterised by number of allele and their frequencies to climatic factors and regional pollution level. We hypothesized that in each population there existed most tolerant or most sensitive tree genetic groups, which could be the genetic basis of further sustainable forest development. From 200 to 400 sample trees with highly polymorphic nuclear SSR markers multiplexed with EST SSRs in each stand were chosen to be genotyped. 12 nuclear microsatellite loci were investigated. DNA was extracted from wood using the ATMAB-method. The genetic groups were distinguished based on allele frequencies using Bayesian clustering approach with STRUCTURE software. Tree reaction to the unfavourable environmental factors was established by applying long-term data set on tree crown defoliation and stem increment dendrochronology. The findings revealed that most productive and healthy trees, which demonstrated the highest tree growth rate and the highest sensitivity to environmental changes (meteorological parameters and pollutants) comprise one genetic group with the highest number of alleles and their frequencies. Meteorological parameters explained more than 70% variation in their stem ring width, meanwhile regional pollution load, mainly by N compounds, additionally increased this explanation rate up to 10%. Pine genetic group which characterised by lowest dendrometric parameters and worst crown condition had no possibility to survive environmental stress, why their existence in natural over-mature pine stand was not detected. The study is based on the results from national project supported by Lithuanian Council of Research "FOREstRESS" (SIT- 3/2015).

Gendiversity, allele frequencies, sustainability,

Theme 2: Forests and Climate Change

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IUFRO17-3884 **Evolutionary history and range-wide adaptive diversity in the European black pine, Pinus nigra Arn.**

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Abstract: The European black pine (Pinus nigra Arn.) is an ecologically and economically important conifer discontinuously and often patchily distributed across different ecological environments and climatic conditions in Europe and around the Mediterranean Basin. In this study, using molecular markers and quantitative traits, we explore the spatial genetic structure of black pine across its range to propose scenarios for the conservation and sustainable use of its genetic resources. Results showed a complete phylogenetic homogeneity among the different P. nigra subspecies. Despite its wide but discontinuous geographic distribution, P. nigra displayed a high genetic diversity within population and low genetic differentiation among populations, revealing the existence of substantial gene flow among the different populations. However, seven different lineages could be identified, possibly linked with the Quaternary history of the species which suggest that the taxonomy of P. nigra could be best resolved by identifying seven subspecies. There were no major differences among subspecies for the relationship between climate and radial growth except for P. nigra salzmannii which presented a negative correlation with the maximum temperature of August, a positive correlation with precipitations of October of the previous year and a negative correlation with August precipitations, no found in other subspecies. The population-level variance component of radial growth was significant but low. The differences in radial growth among individuals and among sites is likely due to phenotypic plasticity rather than strong genetic differences. Finally, although the statistical resolution of climatic niche modelling was rather low, results showed that P. nigra populations analyzed in this study would probably benefit, in terms of radial growth, from a drier climate compared to the one that characterizes their geographic origin.

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-710 **Understanding the Genetic Basis of Local Adaptation to Climate and Genetic Responses to Climate Change in Northern Forest Trees**

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Abstract: The global climate change is subjecting our forests to significant abiotic stresses, which can negatively impact their adaptation, health, productivity and fitness as well as functioning, sustainability and stability of forest ecosystems. Climate change effects are predicted to be more pronounced in northern boreal and temperate forest ecosystems that comprise one of the largest biomes of the world. In order to develop measures to mitigate the negative impacts of climate change by developing and managing well-adapted, genetically diverse and healthy forest resources, it is critical to understand the genetic architecture of local adaptation to climate in forest trees as well as genetic responses and adaptation of forest trees to climate change. Genomics research and applications provide excellent opportunities to address these crucial research needs. I will discuss how genomics, transcriptomics and bioinformatics research and applications can contribute to understand the genetic basis of local adaptation to climate and genetic responses and adaptation of forest trees to climate change by presenting highlights of our own research on these aspects. By using SNPs in candidate genes, SSRs and single-locus and multilocus approaches, we have demonstrated that the genetic architecture of local adaptation to climate is complex and multilocus covariances among populations primarily drive adaptation to local climate in eastern white pine (Pinus strobus). We have identified and characterized genes expressed differentially in response to elevated CO2, drought and co-stressed conditions, their metabolic pathways in black spruce (Picea mariana) and red spruce (Picea rubens), and relationships with physiological traits in black spruce. We have also mapped quantitative trait loci for phenotypic and ecophysiological traits related to growth and adaptation to climate change in black spruce.

Genomics, Transcriptomics, Climate adaptation

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-2276 **Local adaptation of Swiss stone pine (Pinus cembra) to the changing climate at the timberline**

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Abstract: To cope with ongoing climate warming, tree species living at the timberline rely on colonizing yet unforested habitats above their current distribution. This process might be facilitated by the dispersal of beneficial gene variants from lower elevations, i.e. where trees currently experience climatic conditions as expected to occur at higher elevation in the near future. Here we studied the adaptive genetic variation of high- and low-elevation age cohorts in seven populations of the bird-dispersed Swiss stone pine (Pinus cembra), a keystone species of the Alpine timberline ecotone. Due to the limited genomic resources and large genome size, we conducted RNA-Seq to assemble the transcriptome and design probes for exome capture. On the basis of about 27'000 gene targets, we identified around 50'000 SNPs and tested for consistent allele frequency differences among cohorts and elevations, and for associations of allele frequencies with environmental factors. This allowed us to identify genes and environmental factors that are driving adaptation in P. cembra to the changing climate. We were further interested whether alleles that are considered to be adapted to low-elevation environments are also present in juvenile populations at the high-elevation colonization front to match future climatic conditions. Our study is among the first to compare adaptive genetic variation across age cohorts representing different climatic time periods instead of solely relying on contemporary genetic and climatic data. Our results will help to understand if and how locally adapted gene variants will be able to follow shifting habitats as a consequence of climate change.

Climate change,landscape genomics,local adaptation

Theme 2: Forests and Climate Change

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KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-4012 **Detecting adaptive traits in natural alpine populations of Norway spruce (Picea abies [L.] Karst) along altitudinal gradient at regional scale**

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Abstract: A deeper understanding of the genetic mechanisms that control the adaptive ability of forests can be used for management strategies to prepare forests to climate change. Steep environmental gradients represent interesting models to study the adptive genetic process, which is based on the interaction between natural selection and gene flow. In the present study, the genetic basis of local adaptation along an altitudinal gradient were investigated in 18 natural alpine populations of Norway spruce (Picea abies [L.] Karst) sampled on a regional-scale on the Eastern Italian Alps, using Single Nucleotide Polymorphisms (SNPs). To account for patterns of gene flow and spatial genetic structure due to alpine landscape features, sampled populations were subdivided into three geographical groups, each including at least one sampled altitudinal gradient. Hierarchical analyses of molecular variance revealed that most of the genetic variability was found within populations (ca. 99%), and small but significant variation was also found among geographical groups (ca. 0.38%). In order to detect potentially adaptive markers, two distinct approaches were used. First, classical outlier loci detection was applied along the altitudinal gradients using both a Bayesian analysis and a hierarchical island model, which showed contrasting results. Subsequently, Moran's eigenvector maps (MEM) variables, which may account for spatial variation and un-accounted environmental factors, were applied to an allele distribution model, and 19 loci significantly associated to environmental variation were identified. Four of these loci were also detected as outliers by the hierarchical island model. The combined approach of selection scan and spatial analysis method allowed for a parallel investigation of Norway spruce adaptive potential in alpine stands, providing evidence for selective forces acting on adaptive loci that could be relevant in forest management.

elevational gradient, landscape genetics

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1682 **Exome-wide population genetic variation underlying the climate adaption of loblolly pine, Pinus taeda L.**

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Abstract: Relationship between climate variables and genetic variation is the key to understand the genetic basis of adaptation to local environments. By using the SNP association mapping, over 2.8 million exome-derived SNPs were associated with 19 climate and environmental variables in 324 loblolly pine (*Pinus taeda* L.) trees representing 62 collection sites in the southern U.S. A total of 67 SNPs were identified to be associated with 13 climate variables. We used also the multi-SNP model to verify the identified SNPs. The SNPs identified from the single SNP association were significantly correlated ($P < 0.001$ at $\alpha = 0.05$ level) with the climate variables by using the redundancy analysis. The climate variables of mean temperature of the coldest quarter and the temperature seasonality explained the most genetic variation after controlling the geographical variation. Annotation of the identified SNPs showed that 49 out of 67 SNPs reside in coding regions of the tentative genes associated with phenology, stress resistance, etc. These identified SNPs and candidate genes provide valuable resources to understand the local adaption of loblolly pines and for breeding climate change resilient trees.

Association mapping; Climate; Exome; Pine; SNPs

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-862 **Genetic diversity at putatively neutral and adaptive loci in populations of silver fir from marginal and core areas of the species range**

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Abstract: Species range edges are often characterized by small population sizes and high degree of isolation. Evolutionary theory predicts that such populations harbour less genetic diversity than populations from the centre of the distribution range (central-marginal hypothesis), and that under such conditions adaptation is prevented. Nevertheless, empirical studies often do not confirm reduced fitness at the range edges, suggesting that these populations can be locally adapted. This study tests the above predictions using patterns of the genetic variation across 54 populations (with 20 individuals from each) of silver fir (Abies alba) across the western part of the species' natural range, including stands from southern France and Italy, through Switzerland and Germany. Genetic diversity was characterized at 200 putatively neutral SNP loci, and 300 SNPs within candidate gene regions obtained from transcriptome sequencing. We found an overall decrease in genetic diversity and an increase in genetic differentiation from central to marginal populations. Nevertheless, some genetic variants at candidate gene loci were only present in marginal populations. We argue that peripheral populations are of high conservation value because they can potentially be pre-adapted to climatic conditions expected in the future in more northerly central populations.

landscape genetics, conservation genetics

Theme 2: Forests and Climate Change

21 - Dendrochemistry - a tool to asses changes in ecosystem nutrition and forest growth.

K 8 (Konzerthaus Freiburg)

IUFRO17-1074 **Analysis of oak tree rings using LA-ICP MS to record urban pollution from different sources in Terni (Central Italy)**

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Abstract: The present study was aimed at monitoring a pollution legacy in a strongly polluted area, Terni (Italy). A large industrial area that is situated near the urban centre made this relatively small town to be included in a list of the most polluted sites of national interest. We used trees as bioindicators of air pollution in a residential area near a large steel plant, to provide information on relative health risk. The profile of pollutants was detected in tree rings of downy oak (Quercus pubescens) using high-resolution technique of laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). Chromium, Co, Cu, Pb, Hg, Mo, Ni, Tl, W, U, V and Zn contents in tree rings of oak were selected as representative reference of pollution sources in 8 plots, spatially distributed around the steel factory. Trace elements detected in tree rings of trees grown in the study area reflected the industrial activities through time. LA-ICP-MS allowed for detecting pollutants in woody samples with high level of accuracy, and to reflect the pollution history of several years. Tree growth was reduced and elements contents increased in tree rings in trees growing closer to the steel factory.

Laser ablation, tree rings,environmental pollution

K 8 (Konzerthaus Freiburg)

IUFRO17-3620 **Do tree rings record changes in soil fertility? Results from a Quercus petraea fertilization trial.**

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Abstract: Although the dendrochemical approach is regularly considered as a valid way to study past changes in soil chemistry, many observations revealing complex movements of elements in the wood question its real potential to provide markers of temporal changes. Studies conducted on mature trees in experimental design where the changes in soil conditions could be controlled are lacking to obtain a firm answer. Here, we analyzed the tree-ring elemental contents of 44 oak trees cored in a forest experimental design where a NPKCaMg fertilization was applied 40 years ago. Microanalyses of N, Mg, P, K, Ca and Mn were performed on every ring of a 60-year chronology, and for each tree, with a Wavelength Dispersive Spectroscope (WDS) coupled with Scanning Electron Microscope (SEM). These analyses revealed that i) the wood of the fertilized trees displayed a significant higher content in Ca than the control trees but ii) the elemental contents of the rings formed before and after the fertilization event were not different. We concluded that changes in soil chemistry are permanently recorded in the tree rings of sessile oaks but that element translocations preclude any precise temporal monitoring.

tree ring μanalysis fertilization dendrochemistry

K 8 (Konzerthaus Freiburg)

IUFRO17-1735 **Can the interannual variation of phosphorus (P) in tree rings be used as an indicator of P nutrition or P availability?**

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Abstract: Many European forests have become phosphorus (P) limited in recent decades, possibly due to increased nitrogen deposition, soil acidification and improved tree growth. Dendrochemical analyses of P might enable a retrospective analysis of P nutrition of trees and provide valuable information about the effects of short-term changes (recycling efficiency) as well as of long-term environmental trends on the P availability in forest ecosystems.
Therefore, on three Level II sites in Germany (Bad Brückennau, Mitterfels, Tuttlingen and Lüss, which in this order represent a gradient from P acquiring to P recycling systems) we took increment cores of Picea abies and Fagus sylvatica from five dominant trees per site. The P content in the tree rings were was measured by use of a laser ablation system coupled with an ICP-MS.
Tree rings of Fagus sylvatica showed at all sites considerably higher P content than Picea abies. The P availability in the soil does not appear to influence the recycling efficiency of Picea abies on these sites, but for Fagus sylvatica. Interestingly, the declining P concentrations towards the centre of the tree (regarding the distance) was equally rapid at on the Bad Brückenau site, which has the highest soil content of the total and plant available P, and on the Lüss site, with the lowest P stocks. Regarding long-term trends, our analyses show thus far no differences in the direction of temporal trends in P in tree rings between the three sites for Picea abies. For Fagus sylvatica we observed a re-increase of P content in the oldest tree rings at Bad Brückenau. A significant negative trend was observed for Ca in the tree rings on the L üss site indicating an ongoing soil acidification process. Soil acidification has not resulted in a declining trend of heartwood P concentrations, which could reflect on a decreasing P availability.

P nutrition, P availability, tree-ring, LA-ICP-MS

Theme 2: Forests and Climate Change

113 - What is the potential for CO2 mitigation of forest soils?

KG I - 1199 (Uni Freiburg)

IUFRO17-3425 **Impact of forest management on organic carbon storage in soils**

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Abstract: Forest managers have a limited number of possible practices to drive forest ecosystems. Common forestry practices can be roughly listed as follows: i) choice of tree species, ii) regulation of stand density over time, iii) rotation length, and iv) intensity of biomass harvest. All these practices have, or may have, an impact on soil organic carbon (SOC):
Differences of SOC among tree species have been reported in many studies. However, it remains unclear what are the functional traits which control these differences; there are only few general rules. Among other rules (see presentation of A. Boca), it is well-established that gymnosperm forests accumulate more SOC than angiosperm forests in the forest floor layer. Conversely, because of their soil properties, angiosperm forests are expected to store more SOC in soil mineral layers. Similarly, multi-species forests are expected to favour SOC accumulation. But these expectations have not been proven up to now.
Stand density is another possible driver of SOC which lacks sufficient published data to enable generalisation. While dense stands might increase SOC, investigations of bibliographic databases indicate a surprising paucity of data on the possible relationship between stand density and SOC.
Contrary to tree species effect or stand density effect, consequences of rotation length or of biomass harvests are well-documented: frequent disturbances associated with short rotations tend to decrease SOC (mainly in the forest floor layer), and there is a negative relationship between intensity of biomass harvest and SOC (mainly in the forest floor layer, but also in mineral soil layers).
As a whole, forest management is a powerful leverage to increase storage of carbon in soils. But several major unknowns (i.e. tree species, stand density; interactions with land-use history or site properties) remain and should be assessed if we aim to optimise the mitigating role of forests ecosystems in our contemporary climatic context.

soil carbon, management, tree species, disturbance

KG I - 1199 (Uni Freiburg)

IUFRO17-4178 **Impact of afforstations on soil organic carbon stocks - what do we really know?**

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Abstract: Afforestation is the establishment of forest on former agricultural land and has been widely adapted in Europe and North America. Afforestations always increase the biomass carbon stocks but knowledge on the impact on soil organic carbon stocks was scattered and inconsistent. We compiled data from paired plot and chronosequences studies on afforestations in the temperate zone and the tropics and conducted meta-analysis. In the tropics afforestations mostly increase soil carbon but never reached the soil carbon stocks of the primary forest. In the temperate zone afforestations on former croplands enhances soil carbon; afforestations on former grasslands could also lead to soil carbon losses. Around one third of the soil carbon sequestration in afforestations took also place in the forest floor. We discuss underlying mechanisms of soil carbon stabilisation and translocation in the soil profile and the methodological challenges to derive unbiased soil carbon sequestration rates.

land use change, soil organic matter

KG I - 1199 (Uni Freiburg)

IUFRO17-2053 **Changes in soil carbon stocks and turnover rates after land-use conversions in Thailand's tropical forest ecosystems**

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Abstract: Soil is pivotal in the mitigation of global climate change, and is especially functional in tropical forest ecosystems, wherein soil contains an equivalence of half the total carbon stock of these ecosystems. Few studies have assessed how changes in land use affect soil carbon stocks in tropical regions. We studied the differences of soil carbon stocks and turnover rates in a chronosequence of afforested, fast-growing plantations (*Acacia mangium*, *A. auriculiformis*, and *Eucalyptus camaldulensis*), established on devastated grasslands following deforestation of a natural forest in Northeastern Thailand. We determined the soil carbon stocks and stable carbon isotopic ratios (d ^{13}C) in forest, grassland, 12-year-old and 24-year-old fast-growing plantation soils (0-100 cm deep) at various vertical soil depths. We calculated the amount of soil carbon derived from plantation trees and grasses, using the stable carbon isotope mixing model, based on differences in the natural abundance of d ^{13}C in plants with C_3 (trees) and C_4 (grasses) pathways of CO_2 fixation, respectively. Surface soil carbon stocks (0-5 cm deep) were higher in forest (1166 gcm^{-2}) and grassland (1387 gcm^{-2}) soils than in the fast-growing plantation soil samples (12-year-old plantations: 766-992 gcm $^{-2}$, 24-year-old plantations: 768-925 gcm^{-2}). Soil carbon derived from fast-growing plantations were 59-68 % (0-5 cm deep) of total soil carbon in 12-year-old plantations and were 98-100% (0-5 cm deep) in 24-year-old plantations. We found that soil carbon stocks in fast-growing plantations did not recover to that of natural forests and that most of the soil carbon at a depth of 0-5 cm in these plantations changed from grass-derived carbon to tree-derived carbon within a relatively short duration of 24 years. To recover Thailand's soil carbon stocks, exotic fast-growing plantations need to be converted to an indigenous forest state similar to that of a natural forest ecosystem.

Soil Carbon Stocks, Land-Use Change, Tropics, d13C

Theme 2: Forests and Climate Change

113 - What is the potential for CO2 mitigation of forest soils?

KG I - 1199 (Uni Freiburg)

IUFRO17-1850 **Land use, land cover changes and their effects on soil organic carbon stocks in a semi arid forest in Zimbabwe**

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Abstract: Land use and land cover change affects the storage of soil organic carbon (SOC) in forest ecosystems. A study was conducted in a Kalahari sand forest in Gokwe district, Zimbabwe. The aim was to determining effects of forest conversion on SOC stocks over 19 years. Four land use types within Mafungabutsi forest reserve were assessed: natural forest, Eucalyptus camadulensis stand, grassland and cultivated land. Specific objectives were to: determine land use and land cover change and its effects on SOC stocks. Geographic Information System and remote sensing were used to determine land cover change between 1996 and 2015. In each land use, soil and bulk density samples were taken at 10 cm depth interval up to 40 cm and SOC was determined using loss on ignition. Results showed that forest cover decreased by 7 % whilst cultivated land and grasslands increased by 6 and 1% respectively between 1996 and 2015 corresponding to a rate of forest loss of 253/ha/yr. Soil organic carbon losses to due to forest clearance ranged from 0.4 to 2.4 Mg/ha depending on land use. SOC stocks also varied with depth showing grasslands with significantly higher SOC stocks (22 Mg/ha) than eucalyptus woodlot (14 Mg/ha), Natural forest (14 Mg/ha) and cultivated land (12 Mg/ha)at 0-10 cm. At depth below 20 cm, grasslands had lowest SOC stocks, with eucalyptus woodlot and natural forest having statistically similar SOC stocks. In these Kalahari sand forests, clearing of forests for cultivation can results in carbon loss 0.09 Mg/ha/yr, whilst exotic woodlot establishment can regain carbon stocks over time. Grasslands have better surface carbon stocks which are however vulnerable to wild fires. There is need for regularisation of old settlements that are 15 years old or more with proper land use planning. Furthermore, initiation of REDD+ projects can improve livelihoods of neighbouring communities who entirely depend on forest resources whilst mitigating climate change through carbon sequestration.

Land use, Soil, Carbon, Forest, Woodlot, Zimbabwe

KG I - 1199 (Uni Freiburg)

IUFRO17-2851 **Microbial decomposers and their role in forest C-sequestration**

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Abstract: Decomposition of dead plant material and soil organic matter (SOM) is a key ecosystem process mediated by soil microbial communities. Structure, function and activity of these communities, is in turn partly regulated by SOM quality and nutrient availability, which can exhibit great variation in response to plant species, season, site characteristics, and anthropogenic influences such as nitrogen inputs. An understanding of how variations in substrate quality and nutrient availability shape structure and function of microbial saprotrophic communities is pivotal to better understand ecosystem services such as C-sequestration under global change.
Here, we summarize results from three metaproteomic experiments aimed at linking structure and function of microbial decomposing communities to nutrient availability and/or C-sequestration across metaproteomic experiments. Among them are (i) identifying microbial communities active during the decomposition of beech leaf litter from different sites with varying nutrient contents (ii) linking microbial community structure and functions to coniferous forest-floor decomposing processes (iii) measuring the effects of long term forest N-addition on decomposer communities and C-storage in a temperate podzol.
Fungi play a central role as producers of degrading enzymes while bacteria seem to benefit from the presence of fungal enzymes during litter degradation. Cellulase production was observed as an important factor for decomposition. Bacterial phyla that developed on forest floor of different tree species were driven by the N content of their substrate, while fungal phyla seemed to be related to the C-content.
Chronic nitrogen additions decreased the relative abundance of ascomycotal proteins and increased the abundance of plant proteins in the Oe horizon of a 100y old spruce forest. At the same time, organic horizon C storage increased by 30% consistent with the idea that N suppresses fungal decomposers.

community; soil;decomposition; metaproteomics

Theme 2: Forests and Climate Change

113 - What is the potential for CO2 mitigation of forest soils?

KG I - 1199 (Uni Freiburg)

IUFRO17-3265 **Impact of tree species on soil organic carbon**

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Abstract: From alterations of disturbance regimes and climate change to planting of certain species for economic purposes, in many places of the world forest composition has changed dramatically during the past century. With an increasing emphasis in forestry practices on ecosystem services other than wood production, including climate change mitigation, there is a need to better understand forest cover composition and tree species effects on soil organic carbon (SOC) sequestration. As forest soils store as much carbon as aboveground biomass, information about tree species effects on SOC storage is as crucial as understanding C sequestration in tree biomass itself. Here, we summarize the current knowledge about forest composition effects on SOC by comparing broad categories like coniferous vs deciduous, down to specific tree species. A global meta-analysis showed significantly higher forest floor organic carbon pools under conifers compared to adjacent broadleaved stands, but these differences did not translate into the mineral soil with both overstory types having similar mineral SOC pools. As forest floor C is most sensitive to disturbance and warming effects, the question of its future stability should be a major point of discussion when planning for C sequestration in disturbance or warming prone environments. A genus-level analysis showed Picea, Pinus and Eucalyptus as having higher SOC pools than paired broadleaved or coniferous forest stands. However the complexity of SOC sequestration becomes more evident on the species level. For example, aspen (Populus tremuloides) forests show varying pool sizes of SOC even on a watershed scale. When compared to adjacent conifer species they exhibit significantly higher SOC pools in the Intermountain West, USA, but this difference cannot be found over a continental scale. This indicates that decisions regarding the promotion of a tree species should be based on local to regional understanding of the tree species effects on SOC.

KG I - 1199 (Uni Freiburg)

IUFRO17-408 **Effects of tree species change on forest soil carbon in Western Norway (BalanC) - preliminary results.**

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Abstract: Changes in forest management have been suggested as a government policy to mitigate climate change in Norway. Tree species change is one of the major strategies considered, with the aim to increase the annual uptake of CO2 as well as the long-term storage of carbon (C) in forests. The strategy includes replacing native, deciduous species with fast-growing species, mainly Norway spruce. Forests in western Norway host some of the largest soil C pools in Scandinavia, and may potentially function as a long-term C reservoir as well as a large source of atmospheric CO2 through decomposition.
The project BalanC was initiated in 2016 in order to estimate the C storage potential related to tree species in a total of 15 parallel plots of birch and planted Norway spruce at 5 locations in western Norway. In addition to estimates of C stocks in biomass and soils, we investigate soil C processes, soil fungal and earthworm diversity, albedo, and wood product life-cycles. The current presentation focuses on C stocks in soils relative to trees, soil respiration, and soil climate data.
Preliminary results indicate that the soil respiration in spruce was 85 % of the respiration in birch, with a span ranging from 55-151%. The preliminary soil temperature and soil moisture data of the spruce stands were 97 and 73%, respectively, of the birch stands, indicating cooler and drier conditions under spruce which may affect decomposition and C accumulation rates. We expect C allocation in the soil to be affected by tree species, with larger C stocks in the forest floor of spruce stands compared to the mineral soil. Consistent differences in the bulk density of soils under each tree species are likely to be observed, pointing out the need to compare soil C stocks based on equal soil mass. The magnitude of the combined C stock in biomass and soil may increase with planting of spruce, however, we also expect an impact on C stability that will affect the overall mitigation effect of this measure.

tree species change, soil respiration, C stocks

KG I - 1199 (Uni Freiburg)

IUFRO17-3222 **Contribution of deep soil organic matter to forest-atmosphere carbon exchanges: a worldwide isotopic approach**

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Abstract: Deep soil layers (30-200 cm) contain more than half the world soil carbon stock. But the net or gross exchanges of carbon between deep layers and the atmosphere are still poorly estimated. Difficulties in the measurement of fluxes and stock variations in deep mineral horizons, together with the slow carbon turnover therein, are the main obstacles.

We compiled data from 110 sites including 32 forests, where a change in vegetation 13C signature has directly traced the incorporation of plant-derived carbon into the soil. The panel of sites consists in afforestation of C4-dominated lands, FACE experiments, or reciprocally, conversion of forests to C4 crops or grasslands; it covers mid-latitudinal to equatorial climates. The duration of plant-derived carbon tracing ranged from four years to several millenia. Radiocarbon content of world soil profiles is also used to consolidate the 13C analysis.

We show that median carbon ages in mineral soil increase from about one decade at depth zero metre to about one millenium at depth 1.0 m. We infer the distributions of carbon turnover rates and of root contribution to soil organic matter as a function of depth. Plant carbon input to soil organic matter is more surficial in forests than in grasslands and croplands. At the timescale of the century, deep layers (0.3 to 1.0 m) account on average for 20 to 25% of forest soil "active" carbon. We discuss the mechanisms involved in deep C storage and the possible strategies to account for deep soil in carbon balance calculation or modelling.

This study was partially supported by the ANR projects DynaMOS and Dedycas (ANR 14-CE01-0004; ANR 07-BLAN-0222-01)

Carbon storage, soil, organic matter, depth, roots

Theme 2: Forests and Climate Change

113 - What is the potential for CO2 mitigation of forest soils?

KG I - 1199 (Uni Freiburg)

IUFRO17-3618 **What is the capacity and potential for carbon sequestration in forest soils in the UK?**

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Abstract: Afforestation results in sequestration of atmospheric CO2 as trees grow. Different tree species have profound effect on soil functions and potential for carbon storage. Forests planted on mineral soils are generally accepted to result in increased soil C content. However, in some circumstances afforestation on organo-mineral or organic soils may result in substantial loss of soil C due to soil disturbance during forest planting. Forest management practices can change these forest soil carbon storage and dynamics.

Quantification of forest soil C storage, fate and change is vital for underpinning planning and sustainable management to aid forest C sequestration in the future.

This overview presentation will cover past and present forest soil C studies and surveys carried out in the UK. Current forest stocks and stability under main tree species and forest soil types will be summarised. A number of chronosesequence studies with different tree species on different soil types, repeated soil surveys during land use change to commercial conifer forestry, broadleaf woodland and short rotation forestry will be presented. Changes of soil C during forest lifecycle assessed from long term monitoring networks will also be discussed.

forest soil carbon sequestration forest management

Theme 2: Forests and Climate Change

153 - Genetics and Genomics for Conservation, Climate Adaptation and Sustainable Management of

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-990 **Genomics and Forest Quantitative Genetics**

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Abstract: Next Generation Sequencing technologies have increased the availability of genomic data for non-model species such as trees with their known large and complex genomes. The infusion of sequence information in quantitative genetics has permitted the creation of two striking developments; namely the shift from, 1) pedigree-based to genomic-based evaluation and 2) phenotypic-dependent to phenotypic-predicted selection methods. These developments lead to the creation of innovative quantitative genomics approaches such as: a) the pedigree-free and b) the unified single-step (a combination of pedigree and genomic) evaluation methods where the classical Best Linear Unbiased Predictor (BLUP) is replaced by the Genomic Best Linear Unbiased Predictor (GBLUP), leading to the attainment of more precise genetic parameters, better partitioning of the genetic variance and parents and offspring ranking, and c) genomic selection that are transformed the selection classical approaches providing greater gains at a substantially reduced programs' time and costs. Examples demonstrating these development will be illustrated on black cottonwood, white spruce, and Douglas-fir.

Genomics, Breeding, Selection, Genetic Evaluation

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1451 **First analysis of QTL mapping in Cupressus sempervirens for traits of adaptive significance**

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Abstract: Identifying genomic regions associated with adaptive traits is crucial for gene conservation and in breeding for tolerance against climatic change challenges. Herein, parents and 382 F1 individuals of Cupressus sempervirens, a keystone Mediterranean species appearing in two varieties, C. sempervirens var. horizontalis and C. sempervirens var. pyramidalis, were screened using AFLP and SSR markers for constructing horizontalis and pyramidalis variety maps and a consensus linkage map, to provide a framework for QTL mapping. Out of the 1340 AFLP and SSR loci generated, 1271 variable loci segregated in different ratios (1:1, 3:1, 1:1:1:1, 1:2:1) were used for linkage mapping. The consensus C. sempervirens map (LOD=6,r=0.30) consisted of 11 linkage groups, covered all cypress chromosomes (2.105,65 cM), and was used for QTL detection regarding crown form, resistance to the fungus Seiridium cardinale, height and diameter. A crown form QTL was found in Linkage Group 11 (LOD = 3.30). Two possible QTLs, that can be regarded as candidates for additional studies, were found for height and two for resistance to S. cardinale. The long-term mapping population employed permits further dissection of adaptive traits, as future map enrichment and more detailed records of quantitative traits at future ontogenetic stages are possible.

Cupressus sempervirens AFLP, SSR, QTL

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1862 **Enhanced classification of forest tree seedlots with SNPs vs. microsatellites**

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Abstract: Tracing forest tree seedlots and nursery plants back to their sources is important in order to monitor trade and deployment regulations. Genetic markers offer one possibility for such a traceability analysis. Traditionally, we have used multi-allelic microsatellites for this purpose. The success of this approach depends on the quality of the microsatellite markers, which is generally better in broadleaves (*vs*. conifers, because of the latters' larger genomes), and in well-studied species (*vs.* 'orphan' species with fewer available genomic resources). In a pilot study for a Norway spruce (*Picea abies*) seed harvest stand, we have developed a set of robust SNPs from contigs supplied by the Swedish spruce genome sequencing project. The SNPs were assayed by the AmpliSeq strategy on an Ion Torrent machine. After seed lots were collected (in 2003), the adult trees in the seed stand were almost entirely blown down by strong winds. In a comparison between the stored single-tree seedlots and natural regeneration in the stand, as well as remaining adult trees, 255 bi-allelic SNPs achieved a suprisingly precise classification of the seedlot seedlings; unprecedented for conifers in our lab. Single plants among those naturally regenerating at the site of the harvest stand could be assigned to some of those half-sib families. A comparison with microsatellite data, and an outlook for this practical application of genomics techniques will be given.

seed law, monitoring, genomic markers, Picea abies

Theme 2: Forests and Climate Change

153 - Genetics and Genomics for Conservation, Climate Adaptation and Sustainable Management of

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1426 **Transposon activation tagging in trees for gene function discovery**

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Abstract: For black cottonwood (Populus trichocarpa) as the first tree, the sequence of the whole genome of was made available (http://www.phytozome.net/poplar) few years ago. Once the whole-genome information is available for an organism, the challenge turns from identifying the structural genomic parts to understanding the function of many genes as possible. A tag disturbing gene function is useful in many plant species but not appropriate for dioeciously long-lived poplar. Stimulating of gene function by overexpression is known as activation tagging or gain-of-function mutagenesis, and transposons can be applied as tags to do this in a high-throughput, systematic manner. We have transferred the maize transposon Ac in combination with the rolC gene as marker for transposon excision into poplar and successfully tested the usability of transposon-based mutagenesis for induction of "Knock-out" or "Knock-in" ("gain-of-function" or Activation tagging") mutants in a tree species for the first time. Various rounds of activation-tagging experiments were conducted yielding in total more than 12,000 individuals regenerated from putative ATDs transposed calli. From these, hundreds of putatively tagged variants could be isolated including several lines revealing phenotypic variations. In a second step, we improved the activation tagging approach by replacing the rolC gene with a negative selection marker.

Mutagenesis; transposition; functional genomics

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3912 **Stress related overview of two poplar homologues of GRAS/SCL TF: from characterization, cloning to differential expression**

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Abstract: The efforts are being undertaken to enhance salt tolerance of four economically important Serbian poplar clones in order to afforest halomorphic soils that covers the significant area in Vojvodina region. The presented study surveys two putative poplar homologues of GRAS/SCL transcription factors and reviews the current knowledge of its characterization, cloning and their expression analysis. Following blasting of the Populus euphratica PeSCL7 sequence against the Populus trichocarpa genome, two putative orthologs on Scaf_5 and Scaf_7 were identified and screened for nucleotide diversity to search for association with salt tolerance in different clones. By sequence analysis and alignments of both orthologues, SNP markers were identified that differentiate four poplar clones with respect to salt tolerance. After successful amplification of the fragments of a stress inducible PtGRAS16 (Scaf_5) and GRAS17 (Scaf_7) TF genes, cloning was done using Gateway technology. Confirmed cDNA clones were introduced into a plant expression vector for Agrobacterium-mediated transformation. Different phenotypes of the transformed plants in comparison to wild type were obtained implicating eventual diverse genetic potential to salt tolerance. After preparation of cDNA of poplar clones salt stress induced tissue, qPCR was performed to check the nature and level of expression for each gene in 3, 8 and 24 hours using Act9 as reference gene. In Pe19/66 clone, GRAS17 was upregulated in the first 3, 8 and 12 hours on 150mM and 300mM NaCl but downregulated in 24hours on 450mM while expression of GRAS16 was upregulated in 8 hour at 150mM but downregulated in 24 hours and at higher NaCl concentrations. The most important segment of this study was an approach of getting a successful strategy to meet the climate change problem with functional genomic tools in order to obtain the first applicable insights into the future protection of Serbian poplar species.

poplar, GRAS/SCL TF gene, functional genomics

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3772 **Identification and characterization of DNA methyltransferases and DNA demethylases in Salix purpurea, a model plant for bioenergy and phytopharmaceutical products**

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Abstract: The use of bioenergetic plantations as sources of renewable energy is one of the main directives of the energetic policy in Europe. Being part of the natural composition of European vegetation, willows have been recommended as bioenergy crops. Understanding the molecular mechanisms underlying wood formation and the modulation of the cell wall composition can lead to newa breeding strategies of willows for bioenergy purposes. The study of epigenetic players in woody species is important to understand its phenotypic plasticity to a changing environment. Cytosine-5 methylation (Cy5Met) is a major and dynamic epigenetic DNA modification, which is established and maintained by multiple interacting cellular machineries, including de novo DNA methylation and DNA methylation maintenance and DNA demethylation.

Using Salix purpurea plant model for bioenergetics crops and the genome availability for this species, we identified and characterized three classes of DNA methyltransferases involved in de novo and maintenance of DNA methylation (SpurMET1, SpurMET2, SpurMET3, SpurCMT1, SpurCMT2, SpurDRM1 and SpurDRM2) and three classes of DNA demethylases involved in DNA demethylation (SpurROS1, SpurDML1 and SpurDML2).

The results obtained in this study will provide a roadmap for future functional studies of these important families in Salicaceae and other woody species.

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DNA methylation; epigenetic; purple willow

Theme 2: Forests and Climate Change

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KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-2889 **Sustaining Pinus strobiformis into the Future: Reciprocal Transplant Gardens and Disease Resistance Trials**

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Abstract: Pinus strobiformis (southwestern white pine, SWWP) is an important element in the mixed conifer zone of the American Southwest and Mexico. SWWP is dually threatened by a non-native pathogen, Cronartium ribicola (white pine blister rust, WPBR), and climate change (increasing drought). Disease resistance trials underway in Oregon, USA and common garden studies in Arizona, USA have two major objectives: 1) identify maternal families with genetic resistance (both single gene (complete) and partial resistance) to WPBR and 2) identify populations with drought tolerance. Populations with both resistance and drought tolerance are desirable in future landscapes. Reciprocal transplant gardens across an elevational gradient are evaluating the pattern and amount of genetic variation in potentially adaptive traits in 26 populations of SWWP. The common gardens are located at the elevations of 2057m, 2276m and 2688m and vary by 4 degrees C in mean annual temperature. We will present results from morphological and physiological measurements of the seedlings and early results from the disease resistance trials. Understanding genetic variation in these traits across the range of SWWP and the amount of inherent genetic resistance to WPBR will give us insight into the long term prospects for sustaining SWWP.

drought, adaptive traits, invasive species

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3047 **Triploid Aspen in the US: Occurrence and Implications**

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Abstract: Aspen (Populus tremuloides) is one of the most important tree species and forest types in the western U.S., but is declining rapidly in much of its range, and climate change predictions forecast continued dramatic losses of this forest type. An understudied aspect of aspen variation and management is triploidy. A large proportion of aspen in the U.S. Intermountain West is triploid, i.e. it has three copies of its genome. There is a tendency for the larger clones to be triploid, suggesting a physiological advantage, at least historically. Silvicultural practices targeting aspen restoration can be designed to favor or disfavor triploids, so understanding the source of aspen triploidy, the landscape distribution of triploids, and the physiological differences between triploid and diploid aspen is extremely important in the effective conservation and restoration of this important species. I will provide an overview of research on several aspects of aspen triploidy which are relevant to aspen management.

aspen, Populus, genetics

Theme 2: Forests and Climate Change

186 - Changing forest disturbance regimes: Patterns, consequences, and responses

KG I - 1010 (Uni Freiburg)

IUFRO17-1167 **Frontiers in forest disturbance research**

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Abstract: Disturbances such as fires, insect outbreaks and windthrows are an integral part of the natural dynamics in forests around the globe. However, they have recently come into focus because disturbances are changing profoundly in many ecosystems, and because they are increasingly perceived as a major challenge to satisfying the growing societal demand for ecosystem services. This talk serves as an introduction to the session "Changing forest disturbance regimes: Patterns, consequences, and responses". As such it will introduce the session aim and structure, and will subsequently highlight areas of specific interest for understanding the causes and consequences of forest disturbance change. Current frontiers in forest disturbance research that I'll briefly discuss include:
(1) Contextualizing disturbance change: Are recent disturbances truly unprecedented? Are current disturbance regimes still within the natural range of variability of the system?
(2) Understanding the mechanisms and drivers of disturbance change: What are the causes of recent unprecedented disturbance events? What is the role of cross-scale amplification, disturbance interactions, and large-scale synchronization of the disturbance regime?
(3) Resilience to changing disturbances: What are negative feedbacks within the system that can facilitate self-regulation? When and where will changing disturbance regimes exceed tipping points?
(4) Disturbances in a social-ecological context: What do changing disturbances mean for ecosystem services provisioning? How can the paradoxical nature of disturbances be addressed in ecosystem management?
(5) Simulation of changing disturbance regimes: How can we improve projections of potential future disturbance trajectories? What are possible early warning indicators?
In highlighting these current frontiers and providing examples throughout the session we aim to stimulate future research improving our understanding of disturbances in a changing world.

natural disturbances; global change; resilience

KG I - 1010 (Uni Freiburg)

IUFRO17-660 **Reconstructing past disturbance regimes across conifer and broadleaf forests of central, eastern and south-eastern Europe as a baseline to assess future regime shifts**

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Abstract: Until recently, the understanding of the dynamics of European forest ecosystems was largely based on equilibrium, whereby relatively continuous low intensity mortality of canopy trees gave rise to a steady-state forest structure and composition at stand scales and beyond. However, over the last decade numerous empirical studies show that disturbances play an inherent role in driving dynamics across forest types in Europe. Working in two forest ecosystems in the temperate zone of Europe our goal was to reconstruct disturbance regimes at multiple spatial scales. We attempt to answer following questions. Are widespread stand replacing disturbances part of the natural range of disturbance variability in spruce forests or do they reflect a legacy of past management? Are beech forests driven by the small-scale gap dynamics or do periodic higher severity disturbances play an important role in their dynamics? We have used highly spatially and temporally resolved tree ring data of over 15 000 trees from more than 500 plots to reconstruct the past 300 years of disturbance history. The results indicate that both forest types were characterized by a mixed severity disturbance regime over the past. Moreover, despite high spatio-temporal variability of historical disturbances observed on the plot level, we found evidence of disturbance synchronization at the mesoscale level, suggesting these forests are not in equilibrium even at large spatial scales. For spruce forests, broad peaks of disturbances were evident across many sites in the 1820 - 1830, 1850 - 1890, and 1910 - 1930 periods. For beech forests, we found that tree mortality is variable in time; while most decades indicate low severity disturbance, periodic peaks in disturbance were also observed. One of the important conclusions of this work is that past synchronization of disturbances at the mesoscale level may set the stage for another round of future disturbance events, which may be augmented by climate change.

disturbance, forest, beech, spruce

KG I - 1010 (Uni Freiburg)

IUFRO17-2618 **Spatial organization related with disturbance history in monospecific spruce old-growth Carpathians forest**

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Abstract: Forest spatial pattern is an increasing field of research. This has led to different theories (neutral theory, dilution hypothesis, etc.) which are trying to explain the intra and inter-species competition in high species diversity forest. However, spatial patterns were never explained regarding the forest past disturbances. We hypothesized that (1) plots with high disturbance history should have more aggregate patterns and vice versa, plots with low or none disturbance histories should be randomly or regularly distributed. We also hypothesized that (2) local environmental variables (distance to the tree line, slope, etc.) should not explain the spatial pattern at a stand scale. We sampled 219 plots of 1000 m² in 28 stand of spruce forest along the Carpathians Mountains (central Europe). We computed trees and diameter at height breast (DBH) spatial patterns. We cored few trees to have the plot age and the past disturbance history of all the plots and stands. Then we used random forest classifications and regression modelling to compute the explanatory variables explaining the spatial patterns. Our results demonstrated that trees were largely randomly distributed, but aggregation is more likely link to younger plots. On the other hand, 90% of DBH spatial patterns over stands are repulsion, showing a high self-thinning of dominant spruce. The main environmental variables which explain the spatial patterns are the distance from the tree line, the plot age and the time since the last disturbance events.
In conclusion, local environmental variables and last disturbances seems to be predominant proxy to explain spatial patterns structure in old-growth monospecific forest ecosystems.

Spatial pattern, old-growth, disturbance history

Theme 2: Forests and Climate Change

186 - Changing forest disturbance regimes: Patterns, consequences, and responses

KG I - 1010 (Uni Freiburg)

IUFRO17-1557 **Historic, present and potential future fire regimes in the Pacific Northwest**

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Abstract: The Pacific Northwest encompass a wide range of environments and historical fire regimes. This diversity has at least two implications for management: 1) effects of human activity (e.g. forest management, fire suppression, and climate change) on ecosystems are regionally variable; and 2) management for ecosystem resilience to fire and climate change will be most effective when ecological variation is considered. We mapped three major historical fire regimes based on climate, lightning, and fire history: infrequent/high severity fire; moderately frequent/mixed severity fire; and frequent/low severity fire. Effects of fire suppression have been largest in the frequent and moderately frequent fire regimes. Effects of climate change on ecosystems may also be largest in these regimes. Exclusion of fire has led to changes in successional dynamics that feedback to fire behavior. For example, forests that burned frequently and were relatively open are now dense, shady, and may be less prone to fire except under extreme fire weather, when contiguous fuels may lead to larger patches of high-severity fire than under the historical regime. Altered disturbance regimes may change successional dynamics with consequences for ecosystem resilience to future fire and climate change. We discuss management strategies that may mitigate these changes.

fire regime climate change succession

KG I - 1010 (Uni Freiburg)

IUFRO17-161 **Interactions between disturbances: Describing and anticipating complete and complex regimes**

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Abstract: Disturbances are fundamental components of ecosystems and, in many cases, a dominant driver of ecosystem structure and function at multiple spatiotemporal scales. While the effect of any one disturbance may be well understood, the reality of multiple, interacting disturbances which characterize both historical and emerging regimes is more complex. Interactions between events, mediated by physical and biological aspects of the landscape, can cause unexpected disturbance behavior (e.g. larger extents), altered return intervals, or reduced ecosystem resilience and regime shifts. Given the long-lasting effects of disturbances and shifting disturbance rates/drivers, developing a broad conceptual understanding and some predictive ability is crucial.

Interactions between disturbances can be placed into a unified framework around the concept of changing ecosystem resistance or ecosystem resilience. Understanding and predicting disturbance interactions requires disaggregating disturbances into their constituent physical and biotic legacies, identifying the mechanisms which constrain future disturbances behavior (or ecosystem recovery), and determining when and where those mechanisms might be altered by the legacies of prior disturbances. The literature is replete with examples of both positive and negative examples. These can be quantified mechanistically as well as spatially, building on the concepts of disturbance exposure to anticipate when and where these emergent, interactive events may occur. Looking to the future, one can anticipate "cascading effects," by which these interactions extend or reduce the reach of induced alterations to disturbance regimes beyond what is currently anticipated.

Disturbance interactions have the potential to cause large, nonlinear, or unexpected changes in ecosystem structure and functioning - finding generality across these complex events is an important step in predicting their occurrence and understanding their significance.

disturbance, disturbance interactions, resilience

KG I - 1010 (Uni Freiburg)

IUFRO17-2882 **Coupled effects of wind-storms and drought on forest damage in managed coniferous forest in the Western Alps and the Jura mountains**

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Abstract: Wind storms and drought are increasingly causing damage to many temperate forest across Europe, yet very little is known how these key climatic factors interact. The objective of this study is to estimate the roles of drought and wind-storms, and their interactions, on adult tree mortality using 31-year long forest damage time series across 115 stands in six managed, mixed-coniferous forests from the Western Alps and the Jura mountains. For each stand, yearly drought was characterized using the self-calibrating Palmer's Drought Severity Index, and yearly wind-storm time series were inferred from interpolated fields of daily maximum wind-speed. We found that drought increased damage in the most southerly forests, and storms increased damage in all forests in a relatively uniform way. Drought and storms interacted in different ways depending on the specific stand. Based on our data, it seems probable that either drought weakens trees, so that they became more prone to breakage under wind-loading, or excessive rain leads to soil water saturation that make trees more susceptible to overturning in a wind-storm. Our results stress that temporal data is essential to make valid inferences about forest ecological processes involving disturbance events such as wind and drought, and that making inferences about either of these disturbance agents separately can be of limited validity.

mortality, damage, conifer, wind-speed, drought

Theme 2: Forests and Climate Change

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KG I - 1010 (Uni Freiburg)

IUFRO17-375 **Ecological resilience to natural disturbances: Lessons learned from Yellowstone National Park (USA)**

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Abstract: Subalpine forests of Yellowstone National Park (northern US Rocky Mountains) have historically been very resilient to high-severity natural disturbances including wildfires and native bark beetle (Dendroctonae) outbreaks. However, changing climate and disturbance regimes could fundamentally alter successional pathways and carbon storage during coming decades. As temperatures warm, fire-return intervals that ranged from 100 to 300 years during the Holocene are expected to shorten substantially by mid century. Multiple mechanisms may already be interacting to catalyze change in postfire landscapes. Increased fire frequency can compromise postfire tree recruitment if fire-return intervals are less than the time required for young trees to produce an adequate seed crop. Carbon stocks also will not be sustained over the fire cycle if fire-return intervals are less than ca. 90 yrs. Increased size of high-severity burned patches can reduce tree regeneration if patch sizes exceed effective seed-dispersal distances. Even if seed supply is adequate, unfavorable climate (e.g., drought) during early postfire years can preclude tree regeneration. Data from postfire regeneration after recent fires supports each of these mechanisms. In contrast to the robust forest recovery documented after the extensive 1988 fires, Yellowstone's forests may be much less resilient to future disturbances.

fire, succession, Pinus contorta, montane forest

KG I - 1010 (Uni Freiburg)

IUFRO17-643 **Forest biodiversity in the era of changing disturbance regimes: Case studies from Japan**

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Abstract: Considering the substantial and irreplaceable contributions of biodiversity and ecosystem services to society, forest sciences have a large potential to contribute to the integrity and sustainability of our future. When the roles of biodiversity to sustain a variety of ecosystem functions and services are considered, such importance is further emphasized. Although some initiatives aimed at conserving both biodiversity and ecosystem services are emerging, knowledge gaps still exist about their relationships and potential trade-offs in forests. Filling such knowledge gaps is urgently required, because of the unprecedented rate of environmental change. In particular, because of the changing climate and many forms of human influences, forest disturbance regimes are now in the phase of significant changes. By discussing a variety of possible consequences of the changing disturbance regimes on biodiversity in northern forests in Japan, I hereby illustrate priorities and future possibilities in applied ecology studies in forests. In particular, I shed light on existing and emerging ecological theories, which should play an important role in informing forest management.

Disturbance, biodiversity, ecosystem functions

KG I - 1010 (Uni Freiburg)

IUFRO17-1540 **Intermediate severity windthrow effects on forest structure and carbon dynamics in the eastern United States: implications for adaptive management**

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Abstract: Windstorms are an important disturbance influencing temperate forest dynamics. We investigate intermediate-severity windthrow events specifically because these have been under-studied in eastern North America yet may be increasing in frequency with climate change. We quantify effects on residual structure, spatial variability in canopy complexity, stand dynamics, and aboveground carbon storage. The study focuses on mature and old-growth mixed hardwood-conifer sites spanning a range of partial blowdown sizes in the northeastern United States. Using parametric (ANOVA) and nonparametric (NMS ordination) analyses, we compare wind-affected forests with adjacent undisturbed areas, assessing variability within and among four sites up to eight years post-blowdown. The post-blowdown ratio of downed CWD biomass to standing live tree biomass was 2.75 in blowdown stands and 0.18 in reference stands, indicating a large carbon transfer from live to downed pools. However, residual live basal area was substantial, ranging from 20 to 60% of pre-disturbance levels. Spatial variability in leaf-area-index was significantly enhanced by blowdowns, reflected the abundance of dispersed and clustered standing legacies. Despite dramatic structural changes, indices of stand structural complexity and carbon storage remained high. Partial disturbance at our sites released shade-tolerant sub-canopies, but did not recruit a new cohort, suggesting a dynamic in which late-successional composition is maintained rather than regenerating early-successional species. Intermediate wind contributes to structural complexity at stand and landscape scales while maintaining or accelerating shifts towards late-successional composition when advanced regeneration is present. Advanced regeneration thus enhances compositional and carbon flux resilience to this type of disturbance. Our findings will inform adaptive, multi-cohort silvicultural systems designed to emulate partial disturbance dynamics.

Natural disturbance, Legacies, Carbon, Resilience

Theme 2: Forests and Climate Change

186 - Changing forest disturbance regimes: Patterns, consequences, and responses

KG I - 1010 (Uni Freiburg)

IUFRO17-566 **Providing multiple ecosystem services in the face of changing disturbance regimes**

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Abstract: Forests play a vital role in providing ecosystem services to humans. However, changing disturbance regimes are predicted to have strong and predominately negative impacts on forest ecosystem services. Simultaneously, societal demands for ecosystem services are increasing, and new forest functions are gaining importance alongside traditional services such as timber production. Forest managers thus face the challenge to increase service provisioning while at the same time strengthening the robustness of ecosystem services under future disturbance regimes.
Here, we investigated four alternative management strategies, developed in a participatory approach with stakeholders, under seven different climate and disturbance scenarios on a 6500 ha landscape in the Northern Front Range of the Alps in Austria. We quantified the provisioning of four ecosystem services (timber production, climate regulation, erosion protection, and biodiversity) over the next 200 years using the individual-based forest landscape and disturbance model (iLand). iLand dynamically simulates interactions between vegetation, climate, disturbances, and forest management, allowing us to assess the stability and amount of service provisioning under changing conditions and quantify trade-offs between them.
Our results show considerable trade-offs between the level of ecosystem service provisioning and the stability under changing conditions, suggesting a need for adaptation of forest management beyond the business as usual. Strategies promoting mixed forests showed a balanced performance, making them a viable option to ensure ecosystem provisioning in the face of future climate and disturbance changes.

ecosystem services, forest management, disturbance

KG I - 1010 (Uni Freiburg)

IUFRO17-824 **Tools for assessing the impacts of climate variability and change on wildfire regimes in forests**

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Abstract: Fire is an intrinsic element of many forest ecosystems. Fire shapes forest ecosystems' ecological processes, determines species composition and influences landscape structure. However, wildfires may have undesirable effects on biodiversity and vegetation coverage, produce carbon emissions to the atmosphere, release smoke affecting human health, and cause loss of lives and property. There have been increasing concerns about the potential impacts of climate variability and change on forest fires. Climate change can alter factors that influence the occurrence of fire ignitions, fuel availability and fuel flammability. This review paper aims to identify tools and methods used for gathering information about the impacts of climate variability and change on forest fires, forest fuels and the probability of fires. Tools to assess the impacts of climate variability and change on forest fires include remote sensing, dynamic global vegetation and landscape models, integrated fire-vegetation models, fire danger rating systems, empirical models and fire behavior models. This review outlines each tool in terms of its characteristics, spatial and temporal resolution, limitations and applicability of the results. To enhance and improve tool performance, each must be continuously tested in all types of forest ecosystems.

climate change, forest fire, assessment tool

KG I - 1010 (Uni Freiburg)

IUFRO17-1713 **Modeling wildfires in Indonesia with the FLAM model**

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Abstract: The wildfire climate impacts and adaptation model (FLAM) uses a process-based fire parameterization algorithm, capturing complex interactions among burned areas, climate, human activity, and fuel availability. The study is devoted to application of the FLAM to Indonesia and features the following methods. The fuel moisture computation is based on the Canadian Fire Weather Information (FWI) system: the Drought Code (DC) is applied to peatland, while the Fine Fuel Moisture Code (FFMC) is applied to non-peatland biomass available for burning (coarse woody debris (CWD) and litter). The ignition probability functions, conditional on these codes, are identified using the optimization approach, based on the observations provided in the Global Fire Emissions Database version 4 (GFED4). The spatial peatland distribution is based on the GFED4; the biomass available for burning - on the tropical and Global Forest Database maps. Thus, the peat fires block is implemented in the FLAM, including a fire spread algorithm. The human ignition probability is based on the human impact map, developed at IIASA using crowdsourcing. Finally, a filtering approach is implemented in the procedure for calibrating the fire suppression efficiency depending on the fire scale. The FLAM accuracy in modeling burned areas is verified over the historical period 2000-2008.

wildfire model, climate impacts, Indonesia

Theme 2: Forests and Climate Change

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KG I - 1010 (Uni Freiburg)

IUFRO17-2324 **Understanding fire, weather and land cover interactions from long-term terrestrial observations and satellite data in a north to south transect in Europe and North Africa**

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Abstract: Long-term historical fire records extending back to the late 1800s are very rare worldwide. Three such long-term historical fire data have been found for (i) Switzerland, central Europe (1900-2014), (ii) Greece, south Europe (1897-2014), and (iii) Algeria, north Africa (1870-2014), which together with the spatial-explicit reconstruction of recent fire history from Landsat images (1984-2016), give a unique and excellent opportunity to understand fire, weather and land use/land cover (LULC) interactions in a north to south transect.
Differences in bio-geographical characteristics provided by the three study areas, located on a large geographical gradient covering two continents give the opportunity to document the role of fire in different biomes, to explore cross-scale issues and assess how fire-weather-LULC interactions vary across different scales, especially under a climate change context.
The research within the Marie Curie fellowship (GRADIENT) consists of three topics that correspond mainly to three different scales. The specific objectives are: (i) the identification of trends, patterns and relationships between forest fires, weather, land cover and socio-economic variables from long-term observations, (ii) the reconstruction of recent fire history and the assessment of burning patterns and fire selectivity on an annual basis from satellite images, and (iii) the exploration of post-fire vegetation dynamics and recovery for selected large fire events using time series satellite images.
Those objectives will contribute to the better understanding of fire, weather and land cover interactions, and will therefore provide knowledge for fire and land cover management practices, especially under a climate change context. Understanding of post-fire vegetation dynamics and recovery will help the mitigation of short and long-term consequences of fire occurrence. The knowledge acquired from the past will help to understand current processes and project them to future.

KG I - 1010 (Uni Freiburg)

IUFRO17-2257 **Changing climate and forest pest insects in Finland, Observed patterns and future projections**

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Abstract: Neodiprion sertifer is the main pine defoliator in Finland, and outbreaks have been rare in eastern and northern Finland due to cold winters. The outbreak range is predicted to expand with increasing winter temperatures. Pine sawfly outbreaks also show clear patterns with respect to soil fertility, and they may be triggered by drought, but it is difficult to predict future developments.
Outbreaks of Ips typographus and other bark beetles attacking spruce have increased in southern Finland since 2010, probably due to more frequent storm damage and warm summers. The reduction of spruce bark beetle risks through management actions is urgent to ensure the sustainability of forestry.
Cyclic outbreaks of defoliating geometrids (Epirrita autumnata, Operophtera brumata) are typical of the mountain birch forests of NW Europe. The largest outbreaks have killed hundreds of square kilometres of birch forest, having devastating effects on ecosystem services and the condition of reindeer pastures. Due to warmer winters, the incidence of outbreaks is predicted to increase in the continental areas of northern Europe. However, the best-growing mountain birch forests in valley bottoms may experience less damage due to colder winters (temperature inversions) and higher activity of natural enemies.

insect outbreak, defoliation, boreal forest

Theme 2: Forests and Climate Change

108 - Resilience of planted forests under global change : learning from the past preparing next generation

KG I - 1199 (Uni Freiburg)

IUFRO17-2884 **Evaluating forest species response to different climate conditions using REINFFORCE arboreta network**

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Abstract: How forest species will cope with climate change? Can we identify those that will show better performance when subjected to future climate conditions?
In order to address these questions, we propose to improve our understanding on 38 forest species' field performance, represented by at least 3 provenances each, established in 38 arboreta, located along a wide range of climatic conditions, from latitude 37 ° to 58° N (REINFFORCE arboreta network). This will allow reducing the uncertainty of species behavior predictions in response to Climate Change, assessing adaptation measures for Atlantic forest resources and contributing for a successful Sustainable Forest Management.
We are approaching this issue in 3 phases:
i) Determine which species show significant different response within the network's climate conditions range (phenotypic plasticity), using the full range of arboreta and all of the species represented,;
ii) Estimate how climate variables impact each one's growth and survival, for a selection of species that are most economically important/ have contrasting performances, and determine the climate range that can be considered optimal;
iii) Estimate risk probabilities for survival and performance for selected species, under climate change scenarios.

Climate, Forest adaptation, plasticity

KG I - 1199 (Uni Freiburg)

IUFRO17-3162 **Site selection and silvicultural management systems for sustainable plantations in dry and drying climates**

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Abstract: Western Australia has 20% of Australia's 2 Mha of timber plantations (~300,00 ha Eucalyptus and 100,000 ha Pinus). Most plantations were established in the past 40 years and are located in the south west of WA which is characterised by a dry Mediterranean climate, an annual summer drought and deep soil profiles that store the winter rainfall. Since the mid 1970s winter rainfall has declined by 15% and there have been episodic droughts. This has caused significant tree mortality and productivity losses and necessitated the development of management systems that accommodate the high levels of water stress experienced in this region.
A comprehensive understanding of the role of soil water storage in determining productivity and resilience to drought stress and the factors that influence this has been developed. Additionally, silvicultural systems have been developed that match plantation density (LAI) to the available water supply as determined by climatic and soil conditions. For short rotation plantations, site selection (primarily avoiding sites with poor soil water holding capacity) is the primary tool available to ensure sustainable plantations. For longer rotation plantations site selection and manipulating stand density through thinning and fertilization are used to balance productivity and the risk of drought mortality.

drought, soil water, variable climate

KG I - 1199 (Uni Freiburg)

IUFRO17-749 **Academia, NGOs, private and public forest sectors - what proposal for the new generation?**

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Abstract: The loss of natural forests and establishment of plantations have been major causes of public concern - raising questions over governance, land ownership and engagement with the public. The New Generation Plantations platform (NGP) seeks to build people's trust in forestry institutions, NGOs and scientists.
Trust challenges are not new and the IUFRO Task Force on Sustainable Planted Forests For a Greener Future has the objective of improving the interface between science activities and the wider society and policy initiatives related to planted forests.
The Task Force and NGP work together to address the science-society interface and to find innovative solutions. This includes joint events like the Edinburgh 2017 NGP Encounter and recently also collaboration to produce an eBook in celebration of NGP's 10 year anniversary. This publication exemplify stories such: 1) Atlantic Rainforest and The Sustainable Forest Mosaics initiative in Brazil, 2) The Umngeni River in South Africa, 3) Plantations for People in Chile, and 4) Trees in the Desert, Forests for Bioenergy and Bamboo & Climate Change in China. We consider the scientific evidence and the extent to which we have achieved meaningful social change through transformative learning journeys with practitioners, civil society, private and public sectors.

Planted Forests, Science, People, Change

Theme 2: Forests and Climate Change

108 - Resilience of planted forests under global change : learning from the past preparing next generation

KG I - 1199 (Uni Freiburg)

IUFRO17-2223 **Investments in planted forests in southern Europe: an ex-post estimation of returns over the last 15 years**

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Abstract: In southern Europe, where semi-natural forests are characterized by multifunctionality and by declining utilisation rates, planted forests play an increasingly important role, not only in industrial timber and biomass supply but also for their strategic capacity to act as a carbon sink in climate change mitigation.
Investments in the establishment and management of planted forests are driven by the financial returns they generate. In spite of the decisive role of financial profitability in determining planted forests investment choices in southern Europe, scientific literature has lacked studies estimating and analysing their financial performance.
We will present the results of an ex-post estimation of investment returns from southern European planted forests focusing on productive forest plantations over the last 15 years. In specific, the financial profitability dynamics of plantation types and species from Italy, Spain and France will be discussed, also in the light of the impacts of policies and market factors such as subsidies, timber prices and land costs.
The presented outcomes will lead us to discuss the status of planted forest investments in southern Europe, contributing, from a financial perspective, to the discussion on the resilience of these strategic resources in a global change context.

Financial profitability; wood production; carbon

KG I - 1199 (Uni Freiburg)

IUFRO17-1672 **Building climate resilient coastal forests applying assessment of vulnerability to climate change and livelihoods of local people**

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Abstract: Major driving factors were identified to build climate resilient coastal forests applying prominent vulnerability assessments: LVI (Livelihood Vulnerability Index) and IPCC-VI (IPCC-Vulnerability Index) for coastal forests of Bangladesh. Data were collected from four randomly selected coastal regions of Bangladesh for assessing vulnerability. Secondary data on climate variability and coastal deforestation (from satellite images and field documents) were integrated. The results depicted LVI (scale 0 to 1), site1 (Khankhanabad) area was highly vulnerable (0.538) than other vulnerable areas: site2 (Chanua: 0.462), site3 (Gandamar: 0.460) and site4 (Saral: 0.416). However, IPCC-VI (scale -1 to 1) site1 showed higher vulnerability (0.0802) than other high vulnerable areas site2 (0.0325), site3 (0.0210) and site4 (0.0073). The results revealed that vulnerability assessing sub-components: dependency ratio, education Index, land holding index, main occupation, households affected by water for 7 days at a time, households affected by daily high tide, time required to reach market, has significant effects on deforestation. Specific adaptive measures for livelihood through local institutions and REDD+ programs may be potentials to act as alternatives to combat the situation and improve socioeconomic conditions which insure the investments on forests. This study is generic in nature and may be implemented other part of the world.

Vulnerability, Coastal forests, Livelihood , REDD+

Theme 2: Forests and Climate Change

Tropical wetlands for climate change adaptation and mitigation

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1520 **Total and heterotrophic soil respiration as impacted by peat swamp forest conversion to oil palm plantation in Central Kalimantan, Indonesia**

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Abstract: The drainage and conversion of peatlands in the Tropics is a major source of greenhouse gases, especially of CO2. This research evaluated how total and heterotrophic soil respiration changed along a chronosequence of conversion to oil palm. The study took place in and around the national park of Tanjung Puting; it included a primary peat swamp forest and two smallholder plantations aged ten months (OP10M) and five years (OP5). Total and heterotrophic soil respiration were measured over thirteen months in paired control and trenched plots; environmental variables and litterfall were monitored concomitantly. Spatial variability was taken into account by measuring respiration from hummocks and hollows in the forest; close to and far from palms in the plantations. Root trenching was implemented one year prior to beginning the monitoring; a second trenching was performed six months later in the forest and youngest plantation. Annual total soil respiration was very similar at the three sites with rates of 12.9 ± 0.3, 11.6 ± 0.5 and 11.7 ± 0.3 Mg C-CO2 ha-1 in the forest, OP10M and OP5, respectively. By contrast the contribution of heterotrophic to total respiration was lower in the forest (55.1 ± 2.8%) than in the plantations (82.5 ± 5.8 and 72 .2 ± 2.9% in the OP10M and OP5). Post re-trenching values were highly exacerbated at the forest and OP10M and therefore discarded from this calculation. The resulting annual heterotrophic respiration amounted to 7.1 ± 0.4, 9.6 ± 0.8 and 8.4 ± 0.4 Mg C-CO2 ha-1 in the forest, OP10M and OP5. In the plantations total respiration far from palms was higher than close to palms notwithstanding using the rates measured far from palms as an indicator of heterotrophic respiration, as suggested in the literature, would increase the estimates of peat and litter organic matter mineralization by around 20%. Quantifying accurately heterotrophic respiration is essential for evaluating peat net carbon loss or gain but remains a challenge.

CO2, greenhouse gas, trenching, land-use change

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1117 **Greenhouse gases emissions in restored secondary tropical peat swamp forests**

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Abstract: Secondary tropical forests often represent stepping stones for further degradation of peat swamp forests (PSF). Rehabilitation efforts through rewetting followed by enrichment planting or even abandonment may reduce greenhouse gas emissions provided the tenure and legal status of the lands is secured. Emission factors could then be used to quantify the success or failure of the efforts. Seasonal flux of carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) in the Katingan Project - a restoration concession in Central Kalimantan, were measured in two contrasting sites, shrubs and secondary forests growing on peatlands. The mean annual flux of CO2, CH4 and N2O in the shrubs are 14.9 + 1.2 Mg ha-1 yr-1, 50 + 30 kg ha-1 yr-1, 7 + 9 kg ha-1 yr-1 respectively and in restored secondary PSF are 10.6 + 0.8 Mg ha-1 yr-1, 90 + 40 kg ha-1 yr-1, 8 + 10 kg ha-1 yr-1 respectively. These land covers have high but insignificantly different soil carbon stocks of 949 + 56 Mg ha-1 and 1126 + 147 Mg ha-1 respectively. Soil temperature difference between shrubs and PSF responsible for the significant difference of total CO2 emissions between the two land covers. High spatial variability of CH4 and N2O emissions represented heterogeneity of microbial biomass actively involved in methanogenesis, nitrification and denitrification.

restoration, GHG, microbial activity, heterogeity

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2040 **Ecosystem productivity in response to land use change in tropical coastal peatlands**

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Abstract: Tropical peat swamp forests are carbon-rich ecosystems that have been greatly affected by high rates of land use change (LUC). Yet few studies have quantified changes in ecosystem productivity associated with deforestation and LUC. We quantified net primary production (NPP) and net ecosystem production (NEP) in peat swamp forests (PSF), logged PSF (LPSF), early seral (ES) and smallholder - oil palm plantations (OP) in a peat dome of West Kalimantan, Indonesia. LUC and forest degradation resulted in large shifts in NPP and NEP. Logged forests and oil palm plantations had a lower mean NPP (38 Mg CO2-e ha-1 yr-1 and 14 Mg CO2-e ha-1 yr-1, respectively) than PSF and ES (47 Mg CO2-e ha-1 yr-1 and 40 Mg CO2-e ha-1 yr-1, respectively). These sites were net carbon sources having negative mean NEP values (-6.5 Mg CO2-e ha-1 yr-1 and -25.1 Mg CO2-e ha-1 yr-1, respectively). In contrast the peat forests and early seral sites were net carbon sinks (9.1 Mg CO2-e ha-1 yr-1 and 9.1 Mg CO2-e ha-1 yr-1, respectively). PSF is among the most productive terrestrial ecosystems, with a NPP exceeding that of many tropical rain forests and equal to the most productive mangrove ecosystems. While the ES had a similar NEP to the PSF, frequent fires in this cover type likely offset carbon gains during the fire intervals. This study suggests that LUC and forest degradation has shifted tropical PSFs from net carbon sinks to net carbon sources.

Tropical peat forests, oil palm, seral, NPP, NEP

Theme 2: Forests and Climate Change

Tropical wetlands for climate change adaptation and mitigation

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1571 **Variablity of hydraulic conductivity in tropical peatlands**

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Abstract: Tropical peatlands store large amounts of belowground carbon and are vital to the global carbon cycle. Hydraulic conductivity, Ks is used to quantify the ability of water to travel through the soil profile and is needed to estimate the amount of water needed to maintain peat dome saturation and simulate the water table depth and groundwater flow. Little is known about Ks in tropical peatlands and the effects of land conversion on Ks. Thus, we measured Ks in sites representing undrained forests, recently burnt forests, degraded shrub land, and oil palm plantation land cover in West Kalimantan, Indonesia. We estimated Ks at three depths using the piezometer slug test method and measured peat properties: carbon, nitrogen, dry bulk density, ash content, and degree of decomposition. We used hierarchical linear models with an information-theoretic approach to evaluate relationships between Ks, peat properties, and land cover while accounting for spatial dependence. We found that Ks varied by orders of magnitude (0.01 to 10 m d-1) within and among sites. There was strong evidence that Ks was related to degree of decomposition, forested land cover, and depth, but weak evidence for the remaining factors. The large variability of Ks within and among sites and inconsistent relationship with peat properties suggested that Ks should be measured directly rather than estimated with peat properties.

permeability, forests conversion, ecohydrology

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2890 **Is Indonesian peatland loss a cautionary tale for Peru?**

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Abstract: Two countries harboring some of the largest tropical peatland area are Indonesia and Peru. We ask whether the Indonesian experience is a cautionary tale for Peru. Indonesian peatlands are subject to intense human impacts, including drainage, logging, conversion to agriculture, and burning. These cause widespread peatland loss, resulting in high greenhouse gas and smoke emissions, and loss of other ecosystem services. In contrast, Peruvian peatlands are under less pressure, with the greatest being forest degradation along navigable rivers, disturbance for oil extraction, and localized mining. Factors enhancing Indonesian peatlands susceptibility are socioeconomic (government development projects, policy permitting shallow peat use, illegal logging, land tenure issues, incentives for agriculture), geomorphic (peat doming that permits extensive drainage, interspersion of uplands and peatlands), and demographic (high population pressure and road access). In Peru, the largest peatland complex has a compact arrangement with little upland or road penetration, interspersed domed and undomed wetlands, and lower population density. We conclude that peatland integrity in Peru is at least partly a historical and geographic accident, suggesting there are no absolute barriers protecting the Peruvian Amazon from a similar fate to Indonesia. Hence effective policy and science-based management are required to maintain the integrity of these peatlands.

peatlands carbon cycle deforestation degradation

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3302 **Impacts on forest degradation on the carbon stocks of freshwater peatlands in the Pastaza-Marañón river basin of Peruvian Amazonia**

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Abstract: Tropical peat swamp forests (PSF) are characterized by high quantities of carbon (C) stored as organic soil deposits. Accumulation of organic matter is facilitated by waterlogged conditions which slows down decomposition. Globally, Peru has the second largest expanse of tropical peatlands, located primarily within Pastaza-Mara ñón river basin in Northwestern Peru. Peatland forests in Peru are dominated by a palm species - Mauritia flexuosa, which cover ~80% of total peatland area and store ~ 2.3 Pg C. However, hydrologic alterations and land cover change could lead to PSF's degradation and loss of valuable ecosystem services. Therefore, evaluation of degradation impacts on PSF's structure, biomass, and overall C stocks is needed to estimate potential losses of C into the atmosphere as greenhouse gases (GHG) emissions.

This study was carried out at select locations within Pastaza-Mara ñón river basin to quantify PSF's degradation status, C stored in phytomass, and soils. Relationships between of forest degradation and C stocks were explored and role of regional landscape factors such as riverine sediment inputs were evaluated to determine factors that may be influencing peat accumulation processes at a broader scale. This information/knowledge can be utilized to identify sustainable practices that minimizes PSF degradation, and loss of stored C.

Forest degradation, peat swamps, soil carbon

Theme 2: Forests and Climate Change

Tropical wetlands for climate change adaptation and mitigation

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2200 **The effect of peat swamp forest degradation on greenhouse gas fluxes in the Peruvian Amazon**

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Abstract: Carbon-dense peat swamp forest in Peru are recurrently harvested for *Mauritia flexuosa* fruits, which is typically performed by cutting down entire palms. This research aimed to evaluate how biogeochemical cycles are affected by forest degradation. Total soil respiration (R_s), heterotrophic respiration (R_h), CH_4 and N_2O fluxes, litterfall and environmental parameters were monthly monitored for two years in an undisturbed (UD), a moderately (MD) and a highly degraded site (HD). The experimental setup entailed measurements in hollows and hummocks with a standing alive or dead palm. R_h rates were higher in hummocks than in hollows (respectively, UD: 25.9 ±0.5 and 17.5±0.3, MD: 14.1±1.3 and 12.4±1.2, HD: 26.8±4.7 and 18.8±3.0 kg C-CO_2 ha^{-1} d^{-1}). Unexpectedly, CH_4 fluxes did not vary significantly between hummocks and hollows, whereas N_2O fluxes followed the same trend as R_h. GHG fluxes from hummocks with a standing alive or dead palm were the same. However, degradation did reduce the relative hummock area (resp. 18, 10 and 4%). As a result, R_h in the MD site (12.4±1.6 kg C-CO_2 ha^{-1} d^{-1}) decreased as compared to the UD one (18.4 ±1.0 kg C-CO_2 ha^{-1} d^{-1}), while litter input increased (12.2±0.3 and 9.3±0.4 kg d.w. ha^{-1} d^{-1} in the MD and UD, respectively). The HD site exhibited R_h (17.5±1.2 kg C-CO_2 ha^{-1} d^{-1}) and litter input (9.4±0.2 kg d.w. ha^{-1} d^{-1}) rates similar to pre-disturbance levels. CH_4 fluxes were 0.75±0.10, 0.62±0.08, 0.89±0.05 kg C-CH_4 ha^{-1} d^{-1} and N_2O 1.7±0.2, 1.2±0.1, 2.0±0.3 g N-N_2O ha^{-1} d^{-1} in the UD, MD and HD site, respectively. These findings suggest that differentiating hummocks and hollows in GHG flux assessments and accounting for changes in relative hummock areas are essential for evaluating degradation impacts on peat C and N cycling in Amazonian peat swamp forests. These results contribute to build knowledge on emission factors for tropical peat regions outside of Southeast Asia and ultimately might be helpful for supporting conservation.

tropical peat, GHG, Peru, Mauritia flexuosa

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2010 **Ecosystem carbon stocks and emissions arising from mangrove conversions in the Mahakam Delta, East Kalimantan, Indonesia**

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Abstract: Mangroves are recognized as having among the largest ecosystem carbon stocks of all forest types. They face serious threats from high rates of deforestation, land use and climate change. Given their ecosystem services, it is important to quantify values of the conservation of the remaining mangroves. The Mahakam Delta, one of the largest mangrove expanses in Southeast Asia has undergone dramatic degradation due to widespread establishment of shrimp ponds. An estimated 21,000 ha of mangroves were deforested from 2000-2010. This is not sustainable as there has been a 50% decline in shrimp production since 2005.We quantified total ecosystem carbon stocks of mangroves and abandoned shrimp ponds and potential CO2 emissions arising from this conversion. The mean ecosystem carbon stocks in broadleaved mangroves was two fold higher (1023±87MgC.ha-1) than the abandoned shrimp ponds (499 ±56 MgC.ha-1). Clearing of mangroves and draining will lead to decomposition and soil collapse that reduced the soil C stock by 45% or a mean of 393 Mg C. ha-1 and generated a significant amount of potential CO2 emissions. Including the protection, conservation and restoration of mangroves in climate change mitigation strategies is likely a viable option positively benefitting many ecosystem services.

Blue carbon, C dynamics, CO2 emission, mangroves

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3008 **Carbon Stocks of Mangroves on Two Large River Deltas in East Africa**

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Abstract: Mangroves have been shown to not only contain globally-significant carbon pools, storing up to five times more carbon (C) than typical upland tropical forests per area, but also export C to oceanic sediments. Inventories were conducted using a Spatial Decision Support System (SDSS) that provided the framework for detailed logistical planning and field mission implementation to estimate C stocks for mangroves with similar land cover and species in Rufiji and Zambezi River Deltas, respectively. The mean carbon content in biomass ranged from 89.6 to 224.9 Mg C ha-1 in Rufiji and 99.2 to 341.3 Mg ha-1 in Zambezi, respectively. Live tree biomass was the dominant biomass C pool, accounted for about 88% in Rufiji and 89% in Zambezi, respectively. Soils C pool in these two Deltas are the largest, containing 213.7 to 359.5 Mg C ha-1 that accounts for 61.5-70.9% of the entire stock with a mean of 64.3% in Rufiji River Delta, and 354.7 to 644.9 Mg ha-1 that comprises 47% to 72% of the entire pool with a mean of 60.8% in Zambezi River Delta. Both soil and biomass C pools in the mangroves in Rufiji River Delta are lower than those in Zambezi River Delta although the deltas have similar land cover and mangrove species. The difference might be related to disturbances, frequent harvesting in Rufiji, less anthropogenic disturbances in Zambezi in recent decades.

mangrove, carbon stock, east africa, blue carbon

Theme 2: Forests and Climate Change

Tropical wetlands for climate change adaptation and mitigation

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2327 **Impacts of land use on mangrove carbon stocks and greenhouse gas fluxes**

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Abstract: Mangroves provide many ecosystem services to people throughout Southeast Asia and the world. Locally, mangrove trees, trunks and aboveground root structures create habitat for fish, shrimp, and crabs that are important food resources, fiber for house poles and roof thatching, and protection from tsunamis and typhoons. Globally, high levels of productivity coupled with water logged and anoxic sediment conditions result in massive stores of soil carbon that could potentially mitigate increased atmospheric CO2 levels. Nearly 30% of these mangroves have been lost over the last 30 years, and they continue to be lost to deforestation for aquaculture, charcoal production, and development. The conversion of mangroves to other land uses is likely resulting in large reductions in carbon storage and increased greenhouse gas fluxes, yet few studies have documented this and this information is critical to inform policy and management of these ecosystems. Mangrove restoration/rehabilitation projects have also increased in the region, but they typically involve replacing once intact and diverse mangrove forests with monotypic stands of mangrove (e.g., Rhizophora mucronata). It is unclear how effective these restored mangrove ecosystems are at providing similar levels of ecosystem services (e.g., C sequestration) as the intact systems they replaced. We will present results from a study that compared C pools and gas fluxes among intact, degraded, and restored mangrove forests conducted in SE Sulawesi, Indonesia. Quantifying carbon stocks and fluxes in intact, degraded, and restored mangroves will not only provide valuable information for more effective mangrove conservation, it could also allow SE Asian countries to participate in incentive programs such as REDD+ that provide payments for ecosystem goods such as C sequestration.

mangroves, gas flux, carbon stock, SWAMP, land use

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2379 **A global analysis of mangrove ecosystem carbon stocks along broad environmental gradients: results from the SWAMP mangrove plot network**

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Abstract: Mangroves sequester and store large quantities of carbon and are of interest for inclusion in climate change mitigation strategies. In response to the need for a comprehensive knowledge of blue carbon stocks, the SWAMP project established a network of plots to quantify ecosystem carbon stocks of mangroves in the Asia-Pacific, West-central Africa and Latin America (>160 sites as of 2016) spanning large gradients of latitude, soil properties, porewater salinity, and precipitation. Structure ranged from dense low stands (>65,000 ha-1 and often <1 m height) to tall open stands (< 100 ha-1 and >40 m in height). The global mean ecosystem carbon stock for mangroves is 869 Mg C ha-1. Carbon stocks of West-Central Africa (799 Mg C ha-1) are slightly lower than those of Latin America (947 Mg C ha-1) or the Asia-Pacific (1049 Mg C ha-1). Soils (to 3m) comprised an average of 86% of the ecosystem carbon stock. At regional and global scales, total ecosystem carbon stocks were poorly correlated to aboveground carbon pools, precipitation, latitude and soil salinity. The current IPCC Tier 1 default values for mangrove ecosystem carbon stocks is about 526 Mg C ha-1. This study provides an improved estimation of Tier 1 values for these regions.

Blue Carbon, mitigation, IPCC default values

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2888 **Mapping approaches for developing regional estimates of tropical wetland extent, carbon storage, and degradation**

Hribljan, J.* (1); Bourgeau-Chavez, L. (2); Endres, S. (2); Suárez, E. (3); Lähteenoja, O. (4); Draper, F. (5); Hergoualc'h, K. (6); van Lent, J. (6); Bhomia, R. (7); del Aguila Pasquel, J. (1); Wayson, C. (8); Zutta, B. (9); Lilleskov, E. (10); Chimner, R. (1)

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Abstract: Tropical wetlands provide many important ecosystem services, including storing large amounts of carbon, yet are experiencing high rates of land use/land cover change within a changing climate. Therefore, rapid large scale mapping activities are urgently needed to quantify current tropical wetland extent and the rate of degradation. As part of the Sustainable Wetlands Adaptation and Mitigation Program (SWAMP), we are working in South America to develop remote sensing methods to provide detailed mapping of both Amazonian lowland peat swamp forests and high altitude Andean wetlands. We are using a combination of multi-date, multi-sensor radar and optical imagery plus DEMs to improve mapping capability and accuracy, particularly for wetlands, which are both floristically and hydrologically dynamic. Maps are validated with extensive field campaigns that allow high resolution determinations of vegetation cover, wetland type, degradation, and when combined with soils data, detailed belowground carbon inventories. In the Ecuadorian mountains this has revealed high density of small carbon-rich peatlands. In lowland peatlands we are finding patchy small-scale degradation and deforestation. These mapping products will serve as a resource for carbon accounting initiatives, monitoring, mitigation opportunities, and sustainable management of these wetlands.

peatlands, muti-date radar, carbon, wetlands

Theme 2: Forests and Climate Change

190 - Climate change and forest health: insights from the IUFRO Task Force

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1000 **Are forest disturbances amplifying or cancelling out climate change-induced productivity changes in European forests?**

Reyer, C.* (1); Partners, M. (2)

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Abstract: Recent studies projecting future climate change impacts on forests mainly consider either the effects of climate change on productivity or on disturbances. However, productivity and disturbances are intrinsically linked because 1) disturbances directly affect forest productivity (e.g., via a reduction in leaf area, growing stock or resource-use efficiency), and 2) disturbance susceptibility is often coupled to a certain development phase of the forest with productivity determining the time a forest is in this specific phase of susceptibility. The objective of this presentation is to provide an overview of forest productivity changes in different forest regions in Europe under climate change, and partition these changes into effects induced by climate change and disturbances. We present projections of climate change impacts on forest productivity from state-of-the art regional forest models that dynamically simulate forest productivity and the effects of the main European disturbance agents. The study shows that, in most cases, including disturbances in the simulations exaggerate ongoing productivity declines or cancel out productivity gains in response to climate change. In fewer cases, disturbances also increase productivity or buffer climate-change induced productivity losses. Therefore, it is necessary to interpret climate change-induced productivity and disturbance changes jointly to plan adaptation measures.

Forest health, Forest models, Trade-offs

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3022 **Climatic influences on tree-killing bark beetles: A comparison of North American and European species**

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(1) USDA Forest Service, Rocky Mountain Research Station, Logan, United States; (2) Lund University, Dept of Physical Geography and Ecosystem Science, Lund, Sweden; (3) Swedish University of Agriculture, Department of Entomology, Uppsala, Sweden; (4) National Park Service, Inventory and Monitoring Program, Woodstock, United States

Abstract: An alarmingly large number of recent tree mortality events are a consequence of globally increasing temperatures that not only directly influence tree mortality, but also influence tree-killing bark beetles. Bark beetles are among the most significant biotic disturbances of forests globally, and have recently been the cause of conifer mortality across millions of hectares. Tree-killing bark beetles that require live phloem tissue for reproduction have evolved strategies and traits that often result in irruptive population dynamics and landscape-scale tree mortality. Because many life history traits that contribute to irruptive population behavior are temperature dependent, climate change will continue to cause significant alterations in bark beetle population dynamics, both positive and negative. To adequately manage future forests in a changing climate, knowledge of potential bark beetle impacts will be required. Mechanistic phenology models that describe the influence of temperature on voltinism and other measures of population success have been developed for several species that cause significant forest impacts in pine and spruce forests including Dendroctonus ponderosa and D. rufipennis, both currently found in North America, and Ips typographus, a native of European forests. We discuss and compare evolved life history traits of these three bark beetle species. Using climate change projections of temperature to run the phenology models, we describe the potential future impact of changing temperatures on population success. By comparing bark beetle species from different continents with potentially different strategies for population success, our goal is to better understand climate factors that contribute to tree mortality on a global scale.

Climate change, bark beetle, Ips, Dendroctonus

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3351 **A 30 year, acid deposition and climate change field experiment on high-elevation spruce-fir forest structure and function**

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Abstract: In the 1980's, nitrogen (NO_x) and sulfur (SO_x) deposition across the Northeastern US was thought to be causing forest decline across the region. In 1987, a field experiment was established in a high elevation red spruce (Picea rubens Sarge.) forest on Mount Ascutney Vermont, USA to better understand the causes of these declines. The study established a series of four paired treatments and two controls to examine the impact of chronic, low-dose N (15-31 kg N ha-1 yr^{-1}) on forest structure and function. The treatments began in 1988 and continued annually until 2006. During this time, foliar and soil chemistry, basal area growth, regeneration and mortality, tree physiology, litterfall, forest floor organic matter, and nitrogen mineralization and nitrification rates were measured, among other ecosystem level parameters. From 2006 to present the nitrogen additions were discontinued to monitor forest recovery following 20 years of treatment. Many of the stand level measurements were repeated on a four-year cycle. Although the experiment was not originally designed to examine natural climate change and variability interactions, the very long-term nature of the project has provided a unique opportunity to examine how acidic deposition and climate interact regarding forest health. The original hypothesis predicted that the stand would initially exhibit increased growth relative to the controls due to the fertilizing benefits of the added nitrogen, but that eventually growth would slow and lead to increased tree mortality as nitrogen saturation occurred. We further hypothesized that following the decline, the forest would be replaced by more nitrogen demanding species. After 30 years of study, these hypotheses have come to pass, but not in the way that we had originally thought they would. This paper examines how the forest structure and function have evolved of the course of the experiment and extrapolates how continued climate change will impact these stands.

climate change, acid deposition, spruce

Theme 2: Forests and Climate Change

190 - Climate change and forest health: insights from the IUFRO Task Force

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1881 **New development in modelling impacts of ozone and climate change on forests**

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Abstract: In the last decade the atmospheric pollution reached a worrying level in huge areas of North and South hemispheres and, as a consequence of the continuous increasing of anthropogenic emissions, it is expected that global air pollution continue to rise in the next future. Considering the ecosystems and more closely terrestrial vegetation, among different atmospheric pollutants ozone is probably the most damaging to forest and crops frequently reaching high concentrations over large regions of the world. Recently it was found that over 90% of vegetation damage may be due to tropospheric ozone alone, and it could cause reductions in crop yield and forest production up to 30%. The ozone impacts cannot be considered independently by climate conditions, which can alter soil water content, temperature and start and end of the growing season. Considering it, is very important to quantify the impact of ozone on forests in combination with climatic inputs, in the present climate or in a changing one. The modeling is an useful tool to obtain risk analysis information of the combination of ozone pollution and climate change at regional or global scale.

ozone, climate change, regional and global scale

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2439 **Water starvation impacts faster and more severely phenology and growth than carbon starvation in ten years old beech trees.**

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Abstract: The global warming should constrain trees to recurrent extreme events such as drought increasing tree vulnerability to biotic and climatic hazards. To which extent forests will be able to adapt to these changes? Leaf phenology was largely studied and described as an adaptative strategy in relation to global warming. But the drought impacts on leaf phenology remain poorly understood. Moreover, the root and cambial phenologies were little investigated whereas they control tree functioning and productivity and any changes in their phenology may be strategies to cope with climate change.
Besides phenology, growth is a function particularly sensitive to climate variation. Fagus sylvatica is a species whose cambial growth is particularly sensitive to soil water deficit, what is assumed to be an adaptative strategy to adjust carbon allocation and survive. To evaluate this hypothesis, leaf, shoot, root and cambial phenologies and growth were monitored during three years in ten years old beech trees exposed to intense and repeated drought and carbon starvation induced by defoliations. Results show a strong and rapid impact of the drought on both phenology and growth whereas the impact of defoliation appeared with one year delay and strongly with two years delay.

edaphic drought, defoliation, leaf, root, cambium

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-4041 **Tree growth patterns and water relations in beech, spruce, pine and oak trees across Switzerland**

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Abstract: Changes in climatic conditions highlight the need for a better understanding of climatic forcing of tree growth in Central European forests. Within TreeNet, the biological drought and growth indicator network, stem radius changes of 140 tree individuals on 25 study sites across Switzerland were measured since 2011 on 10-min resolution. We jointly analyzed tree growth and water relations derived from stem radius variations of beech, spruce, pine and oak trees.

Main percentage of annual growth of beech, spruce and pine trees happened during a relatively short time span of one to two months. Moving correlation analysis of daily growth values and meteorological conditions indicated precipitation and relative humidity as most important predictors for daily growth rates, independent of species and site conditions. Thus, growth was closely negatively related to the tree's water deficit (TWD) with highest correlations at the beginning of the growing season, followed by a decreasing trend. During peak growth other driving factors became important. This highlights the importance of tree water status especially for growth initiation, and thus, the timing of the drought event as decisive for its impact on tree growth.

Oak trees grew relatively constant and showed high correlations of growth and TWD during the whole growing season, indicating an opportunistic growth behavior.

tree growth, tree water deficit, drought

Theme 2: Forests and Climate Change

190 - Climate change and forest health: insights from the IUFRO Task Force

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1078 **Multi-scale drivers of forest disturbances across European temperate forests**

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Abstract: Forest disturbances in temperate forests have increased substantially over the last decades. Studies suggest that the observed increase is a results of the combined effect of forest management and climate change. However, the underlying drivers and interactions remain poorly understood. In order to increase our understanding of the disturbance dynamics in European temperate forests, we combine Landsat time series analysis and hierarchical modeling to explain recent forest disturbances (1985-2016) across three magnitudes of scale: the stand, landscape, and regional scale. In particular, we hypothesized that while stand scale predictors explain stand scale variations in disturbance severity, the spatial and temporal patterns of forest disturbances are determined by landscape structure and regional scale climate anomalies. Our study sheds light on the multi-scale drivers of recent disturbance pulses in Europe's temperate forests and thus helps to better understand potential future trajectories of disturbances under ongoing climate change.

Disturbance; Climate change; Landsat; Landscape

Theme 2: Forests and Climate Change

166 - Development of Adaptation Strategies for Climate Change using GM Trees

KG I - 1228 (Uni Freiburg)

IUFRO17-2752 **Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia**

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Abstract: The agricultural sector remains the main source of livelihoods for rural communities in Ethiopia, but faces the challenge of changing climate. This study investigated how smallholder farmers perceive climate change, what adaptation strategies they practice and factors that influence their adaptation decisions. Both primary and secondary data were used for the study, and a multinomial logistic regression model was employed to identify the factors that shape smallholder farmers' adaptation strategies. The results show that 90% of farmers have already perceived climate variability, and 85% made attempts to adapt using practices like crop diversification, planting date adjustment, soil and water conservation and management, increasing the intensity of input use, integrating crop with livestock, and tree planting. The econometric model indicated that education, family size, gender, age, livestock ownership, farming experience, frequency of contact with extension agents, farm size, access to market, access to climate information and income were the key factors determining farmers' choice of adaptation practice. In the Central Rift Valley of Ethiopia, climate change is a pressing problem, which is beyond the capacity of smallholders to respond it autonomously. This calls for institutional and policy support and technology transfer. Supporting smallholders with improved technologies can enable them to intensify agriculture and use varieties that are either drought tolerant or mature in short times. As the rainy seasons are becoming more and more unpredictable and uncertain, depending on rain fed agriculture in the district is more unlikely. Hence providing irrigation facilities to use both underground and surface water is vital. Also, creating opportunities for non-farm income is imperative as this helps them engage in less climate sensitive sectors

Climate change,Adaptation,livelihoods,Smallholders

KG I - 1228 (Uni Freiburg)

IUFRO17-3384 **Downregulation of stress associated protein 1 (PagSAP1) improves salt tolerance by upregulating the expression of cation transporters across the plasmamembrane.**

Bae, E.-K.* (1); Yoon, S.-K. (1); Lee, H. (1); Choi, Y.-I. (1); Choi, H. (1); Park, E.-J. (1)

(1) National institute of Forest Science, Suwon, Korea, Republic of (South Korea)

Abstract: Global climate change has increased drought and soil salinity, which in turn required to develop the proper strategy to cope with such detrimental conditions. Stress Associated Protein (SAP) gene family has been emerged as important candidates for improving abiotic stress tolerance in plants. We here investigated the physiological and molecular functions of PagSAP1 in response to salt stress using transgenic poplars. The PagSAP1 knockdown transgenic plant showed strong salt tolerance by accumulating more K+ ion and less Na+ ion compared to those in the control plants, which was induced by the upregulation of cation transporters. Moreover, yeast two-hybrid analysis revealed that PagSAP1 directly interacted with polyubiquitin and voltage dependent anion channel 2.1 (VDAC2.1), suggesting that the downregulation of PagSAP1 enhanced salt tolerance through the regulation of VDAC2.1 protein by ubiquitination. Taken together, we suggested that PagSAP1 might play an important role in engineering new plant varieties with enhanced salt tolerance, which can ultimately expand its cultivation to marginal lands.

PagSAP1, Salt tolerance, Transgenic poplar

KG I - 1228 (Uni Freiburg)

IUFRO17-2631 **Could poplar plants help reduce toxic metals in soil?**

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Abstract: Overexpression of bacterial gamma-glutamylcysteine synthetase in the cytosol of Populus tremula × P. alba produces higher glutathione (GSH) concentrations in leaves, thereby indicating the potential for cadmium (Cd) phytoremediation. However, the net Cd2+ influx in association with H+/Ca2+, Cd tolerance, and the underlying molecular and physiological mechanisms are uncharacterized in these poplars. We assessed net Cd2+ influx, Cd tolerance, and transcriptional regulation of several genes involved in Cd2+ transport and detoxification in wild-type and transgenic poplars. Poplars exhibited highest net Cd2+ influxes into roots at pH 5.5 and 0.1 mM Ca2+. Transgenics had higher Cd2+ uptake rates and elevated transcript levels of several genes involved in Cd2+ transport and detoxification compared with wild-type poplars. Transgenics exhibited greater Cd accumulation in the aerial parts than wild-type plants in response to Cd2+ exposure. Moreover, transgenic poplars had lower concentrations of O2- and H2O2; higher concentrations of total thiols, GSH, and oxidized GSH in roots and/or leaves; and stimulated foliar GSH reductase activity compared with wild-type plants. These results indicate that transgenics are more tolerant of 100 μM Cd2+ than wild-type plants, probably due to the GSH-mediated induction of the transcription of genes involved in Cd2+ transport and detoxification.

cadmium, glutathione, ion flux, phytoremediation

Theme 2: Forests and Climate Change

166 - Development of Adaptation Strategies for Climate Change using GM Trees

KG I - 1228 (Uni Freiburg)

IUFRO17-3659 **Biosafety analysis of genetically modified trees - The European Scenario**

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Abstract: Genetic modification of trees is a new technological approach aimed at achieving improved production and processing properties. Developed traits include increased pest resistance and improved postharvest characteristics of biomass and biofuel. Numerous field trials with GM poplar have been conducted, and few countries have also initiated commercial production. Many countries have initiated risks assessment procedures as GM trees may differ in their risk characteristics from annual crop plants.
An EU-COST (European Cooperation in Science and Technology) Action FP0905, entitled "Biosafety of forest transgenic trees: improving the scientific basis for safe tree development and implementation of EU policy directives", was approved from April 12, 2010, until April 11, 2014 (http://www.cost-action-fp0905.eu). This Action focused on key aspects related to the biosafety of field trials of commercially released genetically modified trees (GMTs). The information obtained should strengthen the scientific bases of policy directives of the European Union (EU) related to the release of GMTs for commercial cultivation in Europe.
The goals of the Action were (a) to analyze the efficiency of existing gene containment strategies to avoid or minimize gene flow; (b) to facilitate efforts to develop site-specific integration of transgenes in tree genomes to minimize variability in transgene expression and pleiotropic effects, (c) to evaluate methods to monitor GMTs in the whole production chain, and (d) to document socio- economic implications in the frame of cost/benefit analysis of GMT plantations. The main objective of the Action was to evaluate and substantiate the scientific knowledge relevant for GMT biosafety protocols by combining the existing information generated in various EU and Non-EU countries.
The results of the COST Action FP0905 were summarized in a book published by Springer (see http://www.springer.com/us/book/9789401775298).

Cost Action; transgenic tree; risk assessment; GMT

Theme 2: Forests and Climate Change

53 - The role of forestry science in promoting resilient and carbon dense forests

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1995 **The Double Standard: Managing forests with and without a plan**

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Abstract: Tanzania's forest policy requires for all forests a technical management plan and for production forests, a harvesting plan. The policy is strictly enforced for village forest reserves. But harvesting has been allowed to proceed in government reserves and forests on general land without a plan. Further, harvesting plans for some village forest reserves - usually prepared by forestry academics with the support of donors - have been found to be irrelevant and ineffective in improving forest management. This study examines the resilience of foresters' faith in scientific forestry even where it is irrelevant an ineffective. It explores the apparent double standard on the basis of Bourdieu's specification of scientific field that bridges science and technology studies and political ecology. The methods employed were interviews with forestry students, academics, foresters, technical advisors, and people in villages; observations of training, other activities of forestry academics, and practices in the forest management field; and review of documentary sources. Internalized dispositions (the scientific habitus) make it more likely for foresters to require technical plans. Due to the scientific habitus, forestry academics and foresters are unable to admit to it when the plans are ineffective as they are preoccupied with valorizing the forms of knowledge they posses.

scientific forestry; habitus; Tanzania

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2127 **Scientification of community forestry in Tanzania: Are communities capable of adhering to scientific prescriptions?**

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Abstract: We explore the capacity of local communities in implementing scientific prescriptions as stated in Forest Management Plans (FMP) and how useful these prescriptions are. The study was carried in Machemba and Sautimoja villages, Southern Tanzania. We collected data through document reviews, interviews and observations. We found that forest fires, grazing and illegal cutting of trees were described in FMP as threats to sustainability of the forests, and should be addressed by early burning, making fire breaks and forest patrols. However, neither firebreaks nor early burning were carried out, forest patrols were carried out only once instead of three times per month due to lack of funds, and the effort to arrest grazing was affected by politics and power relations, which cannot easily be influenced by villagers. We also found that forest committees had limited capacity to supervise harvesting of timber because they cannot calculate tree volume correctly despite being trained. As a consequence of this, a buyer got an extra 50% of wood relative to what he paid for. We conclude that communities have limited capacity to implement prescribed activities as they are constrained by limited resources and knowledge. We recommend promoting experience-based forms of knowledge in managing community forests.

Machemba, Sautimoja, Firebreaks, Patrols, Timber

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-372 **What's the Use of Community Forest Management Plans in Nepal?**

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Abstract: With the official intention to ensure sustainable utilization, community forests in Nepal can only be established subject to a technical management plan that is endorsed by the concerned district forest office. However, the extent to which these plans are in fact used to steer silvicultural interventions is unclear. This paper documents how the plans are rather used to establish and expand bureaucratic control of community forests. Intensive field observations were carried out in six community forests over a period of two years along with a review of their plans and consultations with executive committee members, forest users, and district forest officials. The results revealed that communities did not manage their forests according to the plans. To them, they were mainly bureaucratic documents required for harvesting forest products. In fact, the plans were only consulted in connection with timber harvesting. Ironically, however, the plans' timber harvesting prescriptions were not followed. Instead, forest officials unilaterally reduced the allowed quantity and quality of harvesting following departmental instructions and/or informal decisions made at district forest office meetings. Furthermore, forest officials were involved in selecting and marking tree for felling and post-harvest inspections. They also used the plans to regain control over the forests by including provisions that compelled communities to seek their consent before undertaking any actions related to timber harvesting, marketing of products, general forest operations, plan amendments, etc. These imposed provisions contradict the autonomy granted to community forest user groups under the 1993 Forest Act and 1995 Forest Regulations of Nepal. Accordingly, community forest management plans mainly serve the interests of bureaucratic control, which is entirely against the spirit if not the letter of Nepal's community forestry policy and legislation.

Management Plan, Relevance, Autonomy, Interest

Theme 2: Forests and Climate Change

53 - The role of forestry science in promoting resilient and carbon dense forests

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1605 **The contested role of inventory based management plans in Nepal's Community Forests**

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Abstract: Nepal's forestry legislation requires community forestry user groups to prepare inventory based management plans for sustainable forest management and harvesting of forest products. Several studies mentioned positive changes in forest cover after establishment of community forestry; however the role of management plans in bringing about such change is less examined. Based on the cases of nine community forests in the mid-hills of Nepal, this paper assessed changes in forest conditions and discussed the role of management plans in causing the observed changes. Remote sensing techniques were used in assessing forest cover before and after the inventory and in estimating change. In addition, reviews of management plans, observations of forest management activities, household surveys and interviews with executive committee members are used as a basis for the study. The image analysis showed that forest cover has improved after enforcement of the inventory based management plan. However, the improvement cannot be attributed to the forest management plans as the silvicultural activities in the plans were poorly implemented. Instead executive committee specified their own rules and enforced strict protection measures to counteract disturbances such as fire, grazing and illicit harvesting.These rules may even contradict with the provisions of the plan. The general assembly and executive committee meeting were found to be supreme in designing, formulating and enforcing strict rules for forest conservation and forest product distribution. Furthermore, forest products were found to be harvested less due to a decrease in need for forest products, especially firewood, fodder and grass. Strong enforcement of the rules enforced through executive committee meeting or general assembly, turned out to be one of the main reasons for increasing forest cover. This question the need for inventory based forest management plans with silvicultural prescriptions in community forests.

Remote sensing, Silviculture, Community forest

Theme 2: Forests and Climate Change

68 - Forest Adaptation and Restoration under Global Change

KG I - 1098 (Uni Freiburg)

IUFRO17-3223 **IUFRO TF Forest Adaptatation and Restoration under Global Change - summary of two years work**

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Abstract: In the face of climate and global change forest adaptation and restoration is a key issue for securing forest integrity, vitality and productivity (cf. theme 2 of the IUFRO 2015-2019 strategy). The Task Force is dedicated to globally compile and improve knowledge of how to achieve an optimal adaptation status of forest and forests landscapes. We are introducing the Adaptive Measure (AM) approach by (1) considering all actions that increase adaptive capacity of forests and forest land, (2) combining Adaptive Forest Management (AFM) concepts on stand-scale with Forest Landscape Restoration (FLR) concepts on landscape scale, (3) linking national and trans-national policies, as well as trans-disciplinary expertise in various fields, and (4) integrating experts and working activities among various IUFRO sections. The TF conceptual pathway is following three aims: identifying knowledge gaps, comparing existing activities and techniques, and elaborating best practice approaches.
This talk will present the activities, achievements and further work planning of the TF in order to reach the conceptual targets. This includes the outcome of a online survey on forest adaptation and restoration world-wide and multiple stakeholder workshops and conferences in different global regions.

climate change, adaptation, forest restoration

KG I - 1098 (Uni Freiburg)

IUFRO17-3826 **Addressing governance challenges for forest landscape restoration**

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Abstract: Governance - the process of decision-making - is critical to the success of forest landscape restoration (FLR). Both the governance process and the FLR process inter-relate and influence each other over time. Much has been written about restoration in terms of technical aspects, and while there is still more to learn, as efforts towards larger scale restoration such as FLR are gaining ground, the whole governance dimension is frequently overlooked by practitioners. I argue that governance must be given due consideration if large scale forest restoration initiatives are to be successful but that there is as yet very little understanding or consideration given to this aspect. Governance is particularly important in large scales such as landscapes where there are multiple stakeholders. It is also particularly important when dealing with restoration where the landscape is purposefully modified. Governance is also critical because of the long term nature of the restoration process. I consider what guidance exists in terms of large scale forest restoration and governance, and apply a framework to support the consideration of governance to FLR implementation in 2-3 different case studies. While there is limited guidance on governance and FLR, this framework seeks to support restoration practitioners so that they can better integrate governance in their work.

governance; forest landscape restoration (FLR)

KG I - 1098 (Uni Freiburg)

IUFRO17-1403 **Climate, soil or seed origin: what drives forest growth ?**

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Abstract: Climate is often hypothesized as the sole and major driving force behind forest growth. A plethora of evidence, however suggests that other factors such as edaphic processes and genetics (seed origin) play equally important role. Thus, disentangling the complexity of the drivers of forest growth is a key to our understanding of their effects on forests. Lack of data, especially pertaining to soil and genetic variation often restricts investigation of their relative role on forest growth. Utilizing data from 44 provenance trials of Norway spruce (Picea abies (L.) Karst.) planted across a wide gradient of climate and site conditions in Austria, we identified the major climatic, edaphic and genetic drivers of growth and quantified their contribution to the variation in mean height at age 15. For this purpose various climatic, edaphic and genetic drivers were analyzed within the Structural Equation Modelling (SEM) approach. Contrasting to traditional multivariate approach, the SEMs have the ability to go beyond the consideration of independent processes, allowing the examination of simultaneous influences and its ability to incorporate latent variables, i.e. variables that cannot be measured directly but can be expressed by one or more observable indicator variables. We found that climate and soil characteristics of the planting location are equally important drivers of height growth of Norway spruce. Genetics plays an important but relatively minor role. We conclude that not only adaptive provenances, but also soil characteristics of the planting location should be taken into consideration when designing adaptive management strategies under climate change.

climate change, forest growth, genetics,soil

Theme 2: Forests and Climate Change

68 - Forest Adaptation and Restoration under Global Change

KG I - 1098 (Uni Freiburg)

IUFRO17-383 **Identifying suitable species compositions to mitigate economic risks under climate change - A mechanistic modelling approach under uncertainty**

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Abstract: European forestry has always faced high uncertainties, including those related to future wood prices and risk of forest damages. Climate change will most likely add further uncertainty, for example by altering growth patterns and tree mortality. To reduce the adverse effects of climate change on forest enterprises, a change in forest composition towards more climate-tolerant species is often recommended. However, this could lead to financial losses if the selected species are economically less attractive, whereas the actual consequences of climate change remain uncertain.
An open question is therefore which tree species compositions are most efficient to balance risks and economic returns. The research presented here aims to identify forest management strategies that are economically robust in the face of market and climate risks. For this purpose we present a mechanistic simulation and modelling approach to optimize tree species compositions for example forest enterprises in Germany. This method combines portfolio theory with novel mathematical programming techniques. To quantify the effect of climate change we build on updated survival rates from potential analogue climates. The approach allows us to quantify the economic consequences of climate change when accounting for the buffering effect of tree species diversification and the adaptation of forest composition.

Climate Change;Risk management;Forest Economics

KG I - 1098 (Uni Freiburg)

IUFRO17-3086 **Is Douglas-fir adaptation to drought rooted on provenance variation for cavitation vulnerability?**

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Abstract: Douglas-fir recently suffered significant diebacks following drought episodes. Whether Douglas-fir is able to adapt to the new climatic conditions is a major concern for forest managers and scientists. We investigated the intraspecific variation of cavitation vulnerability, a key trait in plant survival to severe drought stress. We aim to compare the adaptive potential to drought of provenances from part of the Douglas-fir natural area.
We collected branches of a 25 year-old Douglas-fir provenance trial replicated in two sites in the south of France. Four Washington and four Oregon provenances were compared to twenty provenances from coastal and interior regions of California. We collected two branches on twenty trees per provenance for a selection of ten provenances to estimate cavitation vulnerability.
The first results show a relatively low provenance variation for cavitation vulnerability in both sites, with a strong site × provenance interaction. Whether the relatively low between-provenance variation for cavitation vulnerability is a significant improvement of the resistance to drought potential remains an open question. In the next steps we will investigate the relationship between micro-density and resistance to cavitation and use it to extend the adaptation potential study to the 28 provenances and to others genetic trials.

Climate, density, site × provenance interaction

KG I - 1098 (Uni Freiburg)

IUFRO17-1483 **Performance of Nothofagus antarctica seedlings underplanted in different light environments and gap sizes for forest restoration under global change in Chilean Patagonia**

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Abstract: During decades deciduous Nothofagus antarctica woodlands have undergone a process of mortality and degradation. Uncontrolled fires, grazing and browsing by mammals (livestock and hares), and fuelwood collection are principal driver forces of forest degradation. Sings of degradation are the patchy distribution of residual trees, with canopy gaps of different sizes, a lack of seedlings and saplings, and a thick understory. The objective was to evaluate seedling establishment and growth responses respect to gap sizes and light, after two year of outplanting, in two contrasting landscapes, respect to rainfall regimes: Perhumid in Valle California (~2.250 mm year-1, 43 º40'S, 71º43'W, 670 m asl) and Humid in Balmaceda (~570 mm year-1, 45 º50'S, 71º47'W, 615 m asl). Four replicates of three sizes of gaps (small, medium and large) and controls were created in both stands. Five seedlings were randomly outplanted in each gap and 20 in the control area. Furthermore, 25 seedlings m-2 were outplanted in a denser group (nest planting) on each canopy gap and control position. After the first year seedling survivorship was similar between gaps at the perhumid bioclimate (~70-100% survivorship). At the humid bioclimate the survivorship was statistically higher in control treatment (100%) and lower in larger gaps (35%). The survivorship on nest plantig is higher in the perhumid bioclimate (~50-70% survivorship of groups), but no differences were founds between canopy gaps and control position. Root-collar diameter (RCD) and height growths of randomly outplanted seedlings, and nest planting, were not different between canopy gaps. However, RCD and height growths of seedlings are higher in the perhumid bioclimate. Seedling survival and growth is affected by climate condition respect to rainfall regimes, but also it could still be affected by nursery operations, planting stress and acclimation to field.

restoration, seedling survivorship, Ñirre, Chile

Theme 2: Forests and Climate Change

68 - Forest Adaptation and Restoration under Global Change

KG I - 1098 (Uni Freiburg)

IUFRO17-2315 **Plantation forestry in China: research advancement and future perspectives**

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Abstract: China boasts the largest area of planted forests in the world, while challenges and adverse impacts from rapid development of planted forests are increasingly recognized although a substantial research progress has been achieved. China's plantation forestry development has to be transformed from forest area expansion to forest quality and productivity improvement through implementing sustainable forest management aiming to achieve and enhance the multiple ecosystem services while not scarifying timber production. This paper reviewed the development status of planted forests in China, and the recent research progress on the stand productivity, nutrient cycling and carbon sequestration in planted forests. A deep insight into ecological mechanisms to understand soil fertility decline, carbon sequestration and long term stand productivity has been made, which contributes greatly to the increasing resilience and adaptability of planted forests under environmental change. There are increasing understandings of environmental impacts and monoculture practices of planted forests despite some uncertainties. Moreover, tradeoffs among multiple ecosystem services of planted forests are extremely important for achieving sustainability of plantations. Under the changing climate and forestry development strategy in China, multi-functional management of planted forests are highly advocated with an optimal design and option of the selected ecosystem services that best meet its natural environmental conditions while satisfy the interests and needs of different people who depend on ecosystem services, and integrated forest management combined with landscape management for diversifying ecosystem services, enhancing resilience and landscape sustainability should be adopted across scales sustainable development of the plantation forestry in China.

plantations;forest management;carbon sequestration

Theme 2: Forests and Climate Change

111 - Today ignored, rediscovered tomorrow: The importance of minor tree species in future.

K 1 (Konzerthaus Freiburg)

IUFRO17-1499 **Silvicultural practices for wild pear (Pyrus pyraster)**

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Abstract: A model for crown radius (CR) based on DBH and significant quantifiers for wild pear (Pyrus pyraster) will be presented to identify silvicultural practices. To establish the model empirical data of a wild pear population in Western Germany is used. Site measurements include prevailing vegetation, soil characteristics, location and neighbouring trees. Tree measurements include DBH, height, crown radius and quality characteristics. 41 trees have been used for modelling purposes. Selection criteria for the model are residual plots and coefficient of determination (R^2). In order to find a linear relationship, (semi-) logarithmic transformations of the dependent and independent variables have taken place. A backward variable elimination from a full model was used to find significant predictors. The logarithmic model is selected best as residual plots show a homoscedastic distribution and follow a normal distribution around the zero-line. The R^2 of 0.6101 gives an indication of a significant relationship. The final relation can be formulated as: CR= e^(0.61388*ln(DBH)-0.75029), where CR in m and DBH in cm. From the model, tree spacing and number of stems per ha is calculated and silvicultural guidelines for wild pear including planting density and layout, pruning, thinning and regeneration cutting are established.

Pyrus pyraster, silviculture, crown radius

K 1 (Konzerthaus Freiburg)

IUFRO17-3519 **The potential of birch (Betula pendula Roth and B. pubescens Ehrh.) for forestry in Western Europe.**

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Abstract: An increasing number of commercial tree species struggles with climate change and health problems. Along with socio-economic evolution, this highlights the need to adapt forest management and consider more tree species. Birch (Betula pendula Roth and B. pubescens Ehrh.) is an abundant indigenous pioneer tree species in Eurasia. In Western Europe, it has been considered as a weed for decades. However, it is supposed to provide many ecosystem services and, with proper silvicultural treatment and sufficient radial growth, it can also produce high value timber. Indeed, birch is economically important in Northern Europe. The objectives are (1) to review the benefits that birch can provide to cope with global change in the Western European context (e.g. forest sustainability and profitability, timber production, ecosystem services) and (2) since we hypothesize that birch maintains high radial growth if crown is released at early age, to model the radial growth of birch as a function of age, diameter at breast height, crown development and site, through thinning comparative experiments. Those results are useful to highlight the utility of birch and then write silviculture guides.

Birch, forestry, global change, Western Europe

K 1 (Konzerthaus Freiburg)

IUFRO17-2709 **Dynamics in flushing dates of Sorbus torminalis (L.) Crantz half-sibs families - a key issue for adaptation to climate change**

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Abstract: Wild service tree (*Sorbus torminalis* L. Crantz.) belongs to rare and endangered forest tree species in Europe. The species reaches its north-eastern limit of distribution in Poland and their localities are scattered. The aim of the study was estimation of variation in flushing dates of Wild service tree seedlings of half-sibs families of 8 Polish provenances representing geographical occurrence on progeny-provenance plot in Syców (South-West Poland). A one-time assessment of flushing in 6-point scale was reclassified to the estimated sequence of phenological stages. Three models of bud burst for wild service tree: 30, 20, 10 days were elaborated. The assessments were made for each tree to assign a potential date (DOY) of the final stage of bud burst. On the basis of the adopted models, meteorological data (average daily air temperature) and the assumed temperature threshold physiological start of the growing season (threshold - 5 °C degrees) was estimated heat-sum temperature needed to achieve the 6 stage in buds flushing. The earliest bud burst was observed for population Piaski, while the slowest from Zlotoryja. Flushing dynamics within each provenances is the lowest in Zlotoryja, the highest in Strzelce Opolskie and Kolo.

progeny test, population variation, phenology

Theme 2: Forests and Climate Change

111 - Today ignored, rediscovered tomorrow: The importance of minor tree species in future.

K 1 (Konzerthaus Freiburg)

IUFRO17-2872 **How effective are plantings for genetic conservation to facilitate minor tree species in southwest Germany?**

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Abstract: Minor tree species like Sorbus torminalis and S. domestica are among the rarest native trees in Central Europe. Although they produce valuable timber and fruits, and are thought to have a promising future against the background of global change, there is still a distinct lack in scientific knowledge and silvicultural management of these Sorbus species. In order to conserve genetic diversity and simultaneously promote the Sorbus species to forest managers, the federal state of Baden-Wuerttemberg (southwest Germany) provided seedlings of several minor tree species from its own genetic conservation program. Subsequently, thousands of seedlings were distributed throughout the federal state since the late 1980s. In course of this program, number of plants, species, provenience, and the location of planting were documented by the Forest Research Institute Baden-Wuerttemberg (FVA). Now 30 years after eh beginning of this program there are no information about its impact. Therefore, the aim of our study was to analyze the whereabouts of the planted trees and subsequently to evaluate the success of the actions with special regard to the most rare species Sorbus domestica and S. torminalis
Based on the records of the Forest Research Institute Baden-Wuerttemberg (FVA) the locations of the plantings were gathered, and a representative subsample of sites was visited during summer 2016. Next to the number of surviving trees and dendrometrical measures, the vitality of every individual was quantified. Our results show that the successful preservation of minor tree species is directly linked to variety of factors. We found that favorable growth and site conditions, as well as the knowledge of the responsible forest managers and application of sound silvicultural measures are of outmost importance for species persistence.

minor tree species, whereabouts analysis, Sorbus

Theme 2: Forests and Climate Change

68 - Forest Adaptation and Restoration under Global Change

KG I - 1098 (Uni Freiburg)

IUFRO17-1085 **Biodiversity Conservation through Adaptive Forests Management in the Western Ghats Mountain under a Changing Climate**

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Abstract: Changing climate together with environmental degradation and unsustainable use of resources spoils the biodiversity of the Western Ghats Mountain forest of India. The Ghats is a recognized global biodiversity hot spot. Existence of many rare medicinal plants, herbs, precious trees, and hundreds of endemic species of wildlife is threatened. Encroachment and introduction of plantation crops depleted vast area of natural forests. Poachers widely destroyed precious trees such as sandal, rosewood and teak. Hydropower projects submerged large areas of forests. Increasing rainfall seasonality and intensity result in the erosion of the already degraded soil. Because of long dry season and falling groundwater storage, seasonal plants become extinct. Forest fire becomes common. Strong winds uproot big trees. Shift in regional climate may affect the biodiversity significantly. Rules and regulations to protect the forests become farce because of weak administration, corruption and vested political interference. Sustainable utilization of forest products may boost the current economic development and help alleviating poverty of the tribals. Present paper assesses the impact of climate change and environmental degradation on the Western Ghats forest. Current policies and strategies related to climate, forest and environment have been critically reviewed to suggest guidelines for an appropriate adaptation strategy.

Biodiversity, forest, climate change, adaptation

KG I - 1098 (Uni Freiburg)

IUFRO17-1689 **Kawale dry season tree planting, an innovation amidst climate change, Malawi**

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Abstract: Climate change is one of the key environmental issues affecting the world today. In Malawi, deforestation has been on the rise due to high population growth and high demand of wood fuel. Reforestation is one of the ways to fight climate change. In Malawi, reforestation has faced a lot of challenges due to little or no rainfall and heavy rainfall. In this research, a dry season tree planting technique was discovered. 5000 tree seedlings were planted during the dry season and another 5000 tree seedlings were planted during the rainy season and were compared. It was discovered that trees planted during the dry season have stronger roots, soil water holding capacity is improved, grow faster and healthier. Out of 5000 trees planted during planted during rainy season, only 2500 survived. Some were washed away with the rains because of the weak roots. All the 5000 trees planted during the dry season survived. There is need to adapt to this dry season tree planting technique as it will help in sustaining the environment and rural livelihoods.

climate change, environment, reforestation.

Theme 2: Forests and Climate Change

51 - Forest management strategies to enhance the mitigation potential of European forests

KG I - 1010 (Uni Freiburg)

IUFRO17-2828 **FORest management strategies to enhance the MITigation potential of European forests (FORMIT)**

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Abstract: Forest management may lead to continuous carbon sequestration, with timber use acting as an additional storage component. The balance between release from decomposition and sequestration from photosynthesis and storage determines the mitigation capacity of managed forests. In addition, timber applications may substitute high emission materials, and the use of forest biomass as a renewable energy source may substitute fossil fuel, further complicating the net mitigation effect. The EU-FORMIT project develop forest management scenarios for carbon sequestration in Europe, including mitigation measures and management strategies for different regions, and accounting for trade-offs with other forest functions. As part of this, options for carbon storage in forests need to account for historical management practices, regional differences, and management scenarios and modes of operation. This includes options for biofuel use, links between biodiversity conservation and management strategies, and economics of timber production. Mitigation encompasses carbon storage in forests, carbon in forest products, and substitution of fossil fuel. Stand and forest type estimates are scaled up to a European-wide assessment using available forest inventory data supplemented by MODIS remote sensing data allowing extrapolation of detailed analysis over wider areas. Forest management options aimed at mitigation are identified, accounting for trade-offs between forest functions, and including selection of tree species and mixtures, rotation and silviculture techniques, accounting for site differences and regional climate change. The outcome of detailed analysis within the work packages are integrated in scenario analysis for forest management in Europe, distinguishing between carbon storage and substitution associated with product use, with focus on mitigation while considering other forest functions, and accounting for regional differences in environmental and socio-economic conditions.

Carbon budgets, adaptive management, mitigation

KG I - 1010 (Uni Freiburg)

IUFRO17-813 **Climate limits across space and time on European forest structure**

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Abstract: The impact climate has on forests has been extensively studied. However, the large scale effect climate has on forest structures, such as average diameters, heights and basal area are understudied in a spatially explicit manner. The limits that climate places on forest structures dictate the resources a forest may provide and the potential value of the timber there within. The majority of current research either investigates climate impacts on forest pools and fluxes, or on case studies that are used to extrapolate results. A spatially explicit study on how climate affects forest structure over a large region would give valuable information to stakeholders who are more concerned with ecosystem services that cannot be described by pools and fluxes - such as biodiversity, habitat suitability, and market values. In this study we quantified the limits that climate (maximum, minimum temperature and precipitation) places on 3 forest structures, diameter at breast height, height, and basal area. Our results show clear climatic zones of high and low upper limits for each forest structure variable studied. We also spatially analyzed how climate restricts the potential upper limits of each forest structure variable and which climate factors are most limiting. Further, we demonstrated how the climate change has affected 8 individual forests across Europe and then the continent as a whole. We find that diameter, height and basal area are limited by climate in different ways and that areas may have high upper limits in one structure and low upper limits in another. We also found that even though individual forests may have increased in their potential upper limit forest structure values, European forests as a whole have lost, on average, 5.0%, 1.7% and 6.5% in potential mean forest diameter, height and basal area, respectively.

forest climate change limits structure Europe

KG I - 1010 (Uni Freiburg)

IUFRO17-2926 **The mitigation potential of European forests**

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Abstract: Today 40 % of the European land area are covered with forest, and represents half of natural potential forest areal. Tree species composition have been changed versus the potential vegetation and new (non-native) tree species have been introduced to enhance timber production Optimized forest management strategies have increased the supply of forest ecosystem services and the concept of sustainable forest management has been successfully implemented during the last 250 ears. The mission of this paper is to provide an overview of the current status of forest resources and management to supply biomass for a growing bio-economy. We provide (i) the state of biomass/carbon storage within Europe Forests, (ii) a historic analysis in the forces and drivers in carbon storage during the last 100 years, and (iii) show the importance of forest management practices to address the carbon mitigation options of forests in Europe. Satellite driven MODIS and terrestrial forest inventory data are applied. The results show distinct differences in the carbon storage of European forests due to biophysical limits and regional historic drivers in forest management, which directly affect the carbon mitigation option of European forests.

Forest management, Carbon, Mitigation, Europe

Theme 2: Forests and Climate Change

51 - Forest management strategies to enhance the mitigation potential of European forests

KG I - 1010 (Uni Freiburg)

IUFRO17-1396 **The FORMIT growth simulator and its application to projections of forest growth under climate change: A case study on trends in Northern Europe in 2010-2100**

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Abstract: In this paper we describe a new climate-sensitive semi-empirical forest growth simulator developed in FORMIT project and demonstrate it in Northern Europe.

We simulated two different forest management scenarios: business-as-usual forest management, which follows the current forest management rules, and a bioenergy scenario, where increased use of forests for bioenergy was assumed to take place. Both management scenarios were simulated with two alternative cutting levels which assumed that (1) annual cuttings stay at the level of year 2010 and that (2) no maximum limit is set for annual cuttings (other than that implied by the forest management rules). The growth was simulated from year 2010 to 2100 at an annual time step.
The simulations were done for NFI plots from 3 countries in Northern Europe: Finland, Sweden, and Norway. The climate was assumed to develop according to RPC4.5 climate scenario.

In total the following four scenario runs were made:
-1: Business-as-usual management with constant (of year 2010) annual cutting level
-2: Business-as-usual management with unlimited annual cutting level
-3: Bioenergy management scenario with constant (of year 2010) annual cutting level
-4: Bioenergy management scenario with unlimited annual cutting level

In the unlimited cutting levels we still applied recommendations of sustainable forest management which regulated thinnings and rotation lengths. The results indicate that the BAU forest management leads to increasing growing stock of forests in Finland and Norway even though the annual country-level cuttings were unlimited. In Sweden the scenario with unlimited annual cuttings led to decrease in growing stock during 2010-2100 in both BAU and bioenergy scenarios. If simulating growth without any annual cutting limits, the bioenergy scenario had in the end much lower growing stock than the BAU scenario in all three countries.

climate change, forest management, simulator

KG I - 1010 (Uni Freiburg)

IUFRO17-2160 **Incidence of extreme weather events on NPP and Biomass production**

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Abstract: Extreme weather events affect biomass production and forest growth. For instance heat waves, droughts, windstorms or frost can disturb the normal cycle of timber production. Climate change can increase the frequency of extreme weather events and thus significantly change the average growth of forests. Knowledge of the relationship between these extreme events and the growth of the forest can help to predict the evolution of biomass production with climate change and the likelihood of the arrival of these extreme climatic events. The reactions of forests will certainly also change with species and location and will also need to be studied.
The FORMIT project has gathered a lot of climate data, calculated Net Primary Production (NPP) using remotely sensed Leaf Area Index and also collected National forest inventory data across Europe. We have taken advantage of the availability of these data to investigate the link between the extreme climatic event, NPP and forest increment.
The study focused on drought sequences observed in the recent past. The water status of a year was evaluated using the Standardized Precipitation Index (SPI), which gives the probability of observing the difference between the observed rainfall and the average precipitation of the last 30 years.
The relationship between forest increment and the SPI is more difficult to demonstrate due to the fact that tree growth is measured over five-year periods. . The forest growth measures was compared to the same period of SPI. However, during the period 2000 - 2012, it was possible to distinguish an early period (2002-2006) where the climate was mainly dry and warm and a second period (20078-2012) when the climate was mostly wet exactly corresponding to these two periods were compared with the SPI. The comparison was made for different regions and species of France as a case study.

Forest growth, climate disturbance, drought, SPI

Theme 2: Forests and Climate Change

51 - Forest management strategies to enhance the mitigation potential of European forests

KG I - 1010 (Uni Freiburg)

IUFRO17-2361 **Mitigation potential of forest management and wood products use - Simulation study for intensive monitoring plots of Brandenburg, Germany**

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Abstract: Forest ecosystems store large carbon stocks in vegetation, coarse woody debris, and soil. The use of wood products may contribute to the mitigation of climate change by prolonging the carbon storage in harvested wood, and by substituting energy-intensive materials and fossil fuels. We present results of a simulation study for intensive monitoring forest sites of Brandenburg (Germany) to explore the mitigation potential of forest management taking into account wood products use. Two management strategies aiming at maximising yield vs. maximising carbon storage, varying in thinning intensity, harvest fraction, and rotation length, were compared with the business as usual scenario (BaU). Forest growth and carbon storage in forest ecosystems were simulated using a modified version of BIOME-BGC, extended by a management module. The carbon storage of harvested wood products including an assessment of its substitution potential was simulated using the wood product model CASTLE_WPM. On average, the "storage strategy" increased the potential carbon sequestration of the forest sector by 32 t C ha $^{-1}$, compared to BaU. But taking into account the substitution effects, the advantage of the "storage strategy" was overcompensated after 57 years. On the other hand, the lower sequestration potential of the "yield strategy" of -31 t C ha $^{-1}$ lasts for 177 years until overcompensated by substitution effects.

management, C sequestration, wood products

KG I - 1010 (Uni Freiburg)

IUFRO17-2283 **The climate impact and mitigation potential of the European forestry sector**

Cardellini, G. (1); Vial, E. (2); Valada, T. (1); Härkönen, S. (3); Mäkelä, A. (3); Levet, A.-L. (2); Moiseyev, A. (4); Achten, W. M.J. (5); Mutel, C. (6); Solberg, B. (4); Muys, B.* (1)

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Abstract: Among the multiple objectives of forestry, mitigation of climate change is one of increasing interest. While the direct role of forests for sequestering carbon has been studied thoroughly, still very uncertain is the extent to which wood products can contribute to mitigation due to the temporary carbon storage and the substitution effect.
To capture the full mitigation potential of the European forestry-wood chain we developed the Time and Space explicit Life Cycle Assessment (TiSpa LCA) methodology, which allows calculating LCA results for the complete European forestry sector per time period and per region. We used the tool based on input from the FORMIT forest growth model simulator for regional forest growth and harvest data, and from the EFI-GTM forest sector model for wood products consumption and trade. In the analysis we considered all the greenhouse gases fluxes occurring along the chain, taking into account also carbon storage and substitution effects for the portfolio of wood products in use in Europe, together with the impact of their trade.
Results show the future mitigation potential of the European forestry sector for a business as usual scenario in comparison with scenarios of increased forest conservation and increased forest bioenergy use.

LCA, mitigation, wood, sequestration, substitution

Theme 2: Forests and Climate Change

135 - Linkages between carbon sequestration and nutrient and water use efficiency in forests.

KG I - 1009 (Uni Freiburg)

IUFRO17-1793 **Long-term increases in photosynthetic efficiency and water-use efficiency due to CO2 rise did not stimulate diameter growth of tropical trees**

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Abstract: Tropical forests are a crucial component of the global carbon cycle and their responses to atmospheric changes affect carbon cycling and climate systems. The effect of rising CO2 on tropical tree physiology and growth is one of the main determinants of simulations using Dynamic Global Vegetation Models (DGVMs) of the responses of tropical forest to climate change. Yet, validation of a 'CO2-fertilization effect' simulated by these models is restrained by the short duration of forest monitoring studies and the absence of tropical CO2-enrichment experiments. As an alternative, the 40% historical rise in atmospheric CO2 concentration can be used. Tree-ring analyses and the measurement of wood stable isotopes and isotopomers can be used to assess effects of past CO2 rise on tree physiology and growth. Here we present such a study on 12 tree species from Bolivia, Cameroon and Thailand. Analyses of wood cellulose 13C revealed consistent and long-term increases in leaf intercellular CO2 concentrations and marked improvements of intrinsic water use efficiency (iWUE) for all study species. On a subset of one species per site, we also studied wood Deuterium isotopomers of glucose (isomers with isotopic atoms) as a direct estimate of photorespiration-to-photosynthesis ratio. This ratio consistently decreased over the past century, indicating increased photosynthesis efficiency. Despite strong physiological responses to increased CO2 levels, tree diameter growth did not increase in any of the sites, nor for sites combined. Increased (leaf) temperatures, insufficient nutrient availability or a shift in biomass allocation in trees are possible reasons for the absence of growth stimulation. Empirical data such as ours are needed to validate and possibly adapt DGVMs to improve projections of tropical forest responses to climate change. DGVMs may currently overestimate tropical forest carbon sequestration, as the often-assumed strong CO2-fertilization of tree growth does not hold.

tropical trees, growth, physiology, climate change

KG I - 1009 (Uni Freiburg)

IUFRO17-3547 **Extreme drought events and land-use change impacts carbon and water cycling in Mediterranean evergreen forests**

Werner, C.* (1); Dubbert, M. (1); Piyada, A. (2); Correia, A. (3); Costa e Silva, F. (3); Caldeira, M. (3); Pereira, J. (3); Pinto, J. (4); Cuntz, M. (5)

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Abstract: Savannah-type ecosystems account for 26-30% of the global gross primary production with water being one of the major driving factors. Particularly, extreme drought spells may endanger ecosystem functioning as they strongly effect local water balance and carbon sink strength. Here, we quantify changes in the water balance, gross primary productivity, carbon sink strength and tree phenology of a typical Portuguese cork-oak forest under extreme drought. 2012 was the second driest year since 1950 with a strong precipitation anomaly in winter (less than 20% of average rainfall) followed by a dry summer.
Precipitation effectiveness ratio increased up to 122% in 2012 compared to the moist previous year, indicating that evapotranspiration exceeded precipitation input due to groundwater access of the Quercus suber trees. Understorey and overstorey gross primary productions were reduced by 53% and 28% in 2012 compared to 2011. Nevertheless, on an annual basis, the ecosystem remained a carbon sink in both years, but with a 61% reduced sink strength during the dry spell. A significant reduction annual NEE was associated with leaf phenological events of canopy renewal. Annual tree diameter growth was reduced by 63% whereas leaf growth was less affected with leaf area index decreasing only 9% in 2012 in comparison to 2011.
Moreover, tree competition for water and nutrients with understory vegetation was observed. Particularly, land-use change due to reduced management can promote woody shrub invasion, which enhanced drought impacts on dominant cork-oaks. This may cause critical drought tolerance thresholds of trees to be overcome and increasing the probability of tree mortality.
Our results suggest that, if the trend of decreasing annual precipitation and changed precipitation pattern on the Iberian Peninsula continues, sustained effects on local ground water reservoirs, understorey species composition and tree productivity may be expected in the long-term.

KG I - 1009 (Uni Freiburg)

IUFRO17-373 **Water, nitrogen and carbon use efficiencies are not related to drought tolerance in trees subjected to precipitation manipulation**

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Abstract: Plants resource use efficiencies are often viewed as indicators of species drought tolerance and water use efficiency is expected to be maximized under drought conditions when water becomes the most limiting resource. We tested these predictions in pi ñon pine and juniper, two tree species that differ markedly in their drought tolerance and vulnerability to drought-induced mortality, by measuring their intrinsic water-use efficiency (WUEi), photosynthetic nitrogen use efficiency (PNUE) and leaf-scale carbon use efficiency (CUE) in response to an ecosystem scale precipitation manipulation experiment. Increasing water limitation, either seasonally or across treatments, resulted as expected in increased WUEi and decreased PNUE and CUE. Variations in these three efficiencies were, however, stronger in response to water limitation than across species and converged to the same relationship against precipitation for pi ñon pine and juniper. This contradicts the paradigm that resource use efficiencies are indicators of a functional strategy or of drought tolerance and shows that plasticity in WUEi, NUE and CUE is associated with low carbon acquisition during drought.

drought tolerance, ressource use efficiency

Theme 2: Forests and Climate Change

135 - Linkages between carbon sequestration and nutrient and water use efficiency in forests.

KG I - 1009 (Uni Freiburg)

IUFRO17-3010 **Effect of nitrogen deposition on C-sink potential of deciduous forest ecosystems: a permanent field-scale manipulation experiment in South Tyrol (Italy).**

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Abstract: In last decades, net primary productivity (NPP) increases have been reported in temperate and boreal forests. This has been related to the human-induced increased nitrogen (N) depositions, however the role of this perturbation is still debated. In Europe, long-term N addition experiments are scarce and mainly located in boreal conifer forests, where N fertilizers are applied directly to the soil, leading to contrasting results. In fact, in the soil there is high competition between plants and microbes for available N, while a large amount of N from atmospheric depositions is directly absorbed by tree canopies. To better understand the long-term effect of N depositions on deciduous forests in the Alpine region, an experimental site has been established in a sessile oak (Quercus petraea) stand near Monticolo (Bolzano province, Italy). Since May 2015, N fertilization is applied on 6 circular experimental plots (12 m radius) by applying a NH4NO3 solution above the tree canopies or directly to the forest floor (3 replicates per treatment). Three unfertilized plots where established as control. The fertilizer is applied 5 times during the growing season, for a total of 20 kg of N ha-1 year-1. Changes in C stocks in soil and plant compartments are measured yearly to estimate NPP and net ecosystem productivity (NEP). The fate of the added nitrogen is assessed by using 15N-labelled fertilizer, allowing the calculation of a 15N mass balance. Other investigations are performed to identify the ecosystem's adaptation to the modified environmental conditions. These include the characterization of the fungal and the bacterial composition within the phyllosphere via Illumina sequencing and Real Time PCR quantification of two marker genes. . Results from the first 2 years of manipulation will be presented.

N-deposition; C-sink; deciduous forest; N cycling

KG I - 1009 (Uni Freiburg)

IUFRO17-2667 **Increasing droughts and tree density reduces European beech response to increasing atmospheric CO2 concentration**

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Abstract: Anthropogenic influences in the biogeochemical cycle of C have produced a rise in atmospheric CO2 concentration (Ca), together with increasing temperatures and an altered rainfall distribution. Rising Ca is likely to enhance trees' water use efficiency, which would promote greater growth rates. However, a diminishing response to increasing Ca and a long-term growth- intrinsic water-use efficiency (iWUE) uncoupling have been previously reported for several forests. In this study, we assessed growth and water-use efficiency relationships by creating 34-year series (1980-2013) of basal area increment (BAI) and iWUE with annual resolution of European beech (Fagus sylvatica L.) at two contrasting sites in the SW Pyrenees with Mediterranean and continental conditions. Besides, we investigated the response to rising Ca of young trees born before and after 1950 at the Mediterranean site by analysing the 30 innermost tree-rings (5-year resolution). A positive relationship between growth and iWUE was found that was significant only at the Mediterranean site. Such results suggest a CO2 fertilization effect, especially in the drought-prone sites. However, we report a decreasing sensitivity of iWUE and growth to increasing Ca along the twentieth century. We propose that a combined effect of increasing water shortage and competition intensification due to forest densification, resulting from increased abandonment of both agricultural fields and forest management practices, as an explanation of such loss of sensitivity to CO2.

radial growth, stable carbon isotopes, competition

KG I - 1009 (Uni Freiburg)

IUFRO17-651 **Linking nutrient response efficiency and carbon storage in forest and agroforestry systems in Germany**

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Abstract: While forest woody biomass serves as a long-term carbon storage, trees in agroforestry are regularly harvested for fuel production, which leads to short-term carbon storage and release. Both long- and short-term carbon storage of trees depend on productivity, which is limited by soil nutrient availability. Nutrient response efficiency (NRE) is an index of plant productivity ratioed to soil nutrient availability. The patterns of NRE with levels of nutrient availability can illustrate ranges of soil nutrient levels where nutrient limitations, optimums and nutrient saturations occur. In an unmanaged mixed-deciduous forest in Germany, *Fagus sylvatica* shows higher NRE and faster growth rates when planted in mixed stands with *Tilia cordata* and *Carpinus betulus* in contrast to mono-species stands, because in mixed stands *Fagus sylvatica* was able to benefit from the nutrient-rich litter of the surrounding species. Likewise, strips of *Populus nigra* x *Populus maximowiczii* in agroforestry may profit from nutrients added through fertilization in adjacent crop strips. The underlying mechanism is facilitation, where a species profits from the presence or soil management practice of another. These examples show that knowledge on NRE of specific tree species has a large potential to increase long- and short-term carbon storage in forest and agroforestry systems.

nutrient response efficiency, carbon, agroforestry

Theme 2: Forests and Climate Change

135 - Linkages between carbon sequestration and nutrient and water use efficiency in forests.

KG I - 1009 (Uni Freiburg)

IUFRO17-1760 **Uncertainty about future nitrogen availability dominates boreal forest growth projections**

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Abstract: There is broad consensus among scientists that the capacity of forests in the boreal zone to take up carbon will increase as a result of climate change. However, boreal forests are strongly nitrogen limited. This may hamper the potential increase in GPP for forest productivity and carbon sequestration, but little is known about the impact of climate change on nitrogen availability in forests.
Here we use OptiPipe, a model of optimal carbon and nitrogen co-allocation to analyse the role of nitrogen availability in growth limitation under climate change in Finland. We predict changes in metabolic rates related to the C balance using existing models and data, and we explore three alternative, plausible scenarios of N availability under climate change. Three climate scenarios based on three Representative Concentration Pathways - RCP2.5, RCP4.5 and RCP8.5 - are used for projecting changes of daily temperature, precipitation, vapour pressure deficit and solar radiation for periods 2011-2040, 2041-2070 and 2071-2100. We use a mean among 5 climate models, combined with respective CO2 concentrations (IPCC AR5). The results will be presented across Finland on a 10 km x 10 km grid.
The results indicate that NPP and woody growth will either increase, decrease, or remain unchanged, depending on respective changes in N availability. These effects are due to environmental impacts on metabolic rates combined with optimal co-allocation of N and C. We analyse the uncertainty of our projections in relation to natural variability in climate, uncertainty in climate models, parameter uncertainty in model components, and uncertainty about N availability in changing climate. The results suggest that the major uncertaintiesstem from our limited understanding of the mechanisms related to N availability.

KG I - 1009 (Uni Freiburg)

IUFRO17-2540 **Interactions in the efficiency of N and P use for forest litter production**

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Abstract: Plasticity in the efficiency of nutrient use for forest production potentially contributes to balanced nutrition despite imbalances in nutrient supply. We examined this possibility by quantifying litter nutrient use efficiency (NutrUE, litter C:nutrient) in a nitrogen x phosphorus fertilization experiment in hardwood forests in the northeastern US. We tested the hypotheses that litter NutrUE is higher where nutrients are more limiting, and that elevated availability of one nutrient leads to higher NutrUE of the other nutrient. The relative basal area increment of individual trees responded significantly to P but not to N addition, suggesting P limitation of productivity. Consistent with P limitation and supporting our first hypothesis, litter PUE declined strongly in response to P (24% lower than controls; p=0.007). The response of NUE to added N was relatively weak (7% lower than controls; p=0.08), and the NUE response to P was greater than that to N (11%; p=0.005). The effect of P on NUE supports our second hypothesis and is consistent with our observations that P addition has suppressed levels of resin-available N relative to controls. Responses by NutrUE that we show here support the idea that efficient use of limiting resources can contribute to balanced nutrition.

NUE, P limitation, forest productivity

Theme 2: Forests and Climate Change

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Room "Colmar" (Novotel Freiburg)

IUFRO17-485 **Wind Disturbance in European Forests in a Changing Climate**

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Abstract: Wind is one of the main disturbance agents in both natural and managed forests. Recent evidence suggests that wind damage to forests is increasing due to a combination of changes in forest management practice and the changing climate. The effect of wind damage is to reduce the carbon sequestration of forests, to increase greenhouse gas escape from disturbed forest soils and to generally lead to a reduction in most ecosystem services such as wood production, recreation, and water quality. In order to understand the impact of wind disturbance on forests and exchange of carbon dioxide, water vapour and nitrogen between the biosphere and the atmosphere we have implemented a version of the hybrid mechanistic, ForestGALES, in the land surface model, ORCHIDEE. This allows estimation of the impact of land use and climate change on carbon and nitrogen budgets at a regional, continental or global scale. The new version of the wind damage model is called WINDFALL and we have been testing the model predictions against recorded wind damage in Southern Sweden following Storm Gudrun in 2007 and in South-west France following Storm Klaus in 2009. We will run simulations into the future of how climate change will affect the levels of wind damage to European forests, and how these changing levels of damage will affect European forest structure and carbon sequestration

Room "Colmar" (Novotel Freiburg)

IUFRO17-2490 **What role does storage function play in the death of beech trees?**

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Abstract: Carbohydrate storage plays a key role to sustain growth, health and survival of forest trees. Current assimilation and/or internal reserves supply soluble carbohydrates for maintenance, growth and reproduction. Seasonal dynamics of non structural carbohydrates (NSC) have been well assessed in several temperate forest key species (Quercus, Fagus). However, there are major scientific uncertainties in our understanding of drought-induced tree mortality. In particular, the contributing of stored NSC to sustain internal plant metabolisms against abiotic stress or the existence of NSC thresholds associated to tree death are poorly understood. Using a dedicated experimental design, 10-year-old Fagus sylvatica have been submitted for three years to repeated artificial defoliation and intense soil water deficit. NSC storage and annual growth have been assessed in above and below compartments of control and stressed trees at key physiological dates among the seasons. Our results show clearly that following 3 years of treatments, NSC amounts and partitioning among tree structures were markedly altered in response to extreme drought and defoliation leading to death for some individual trees. According to our results, it seems that storage function was favoured against growth under limited resource, reinforcing the concept of active accumulation.

NSC, storage, drought, defoliation, mortality

Room "Colmar" (Novotel Freiburg)

IUFRO17-1315 **Natural regeneration of Picea abies (L.) Karst. after strip cutting in the Swiss Alps: a retrospective study**

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Abstract: Cutting practices in the Swiss Alps protection forests have changed recently. Instead of selective cuts, strip cuts of variable size are increasingly used. Concerns about regeneration success in the resulting gaps have motivated a retrospective study on the factors influencing natural regeneration of Picea abies in 30 cuts, selected in mature spruce-dominated montane and subalpine forests differing in site and stand conditions. The cuts were executed 7 - 23 years ago and were 20 - 88 m wide. Sampling in cuts, forest edges and adjacent stands included the assessment of microsite characteristics on transects and circular plots to assess presence, density and size of saplings. Logistic and multifactorial regression models were used to test the influence of management and site factors on spruce regeneration.
Sapling density varied largely between the sites (median: 0 - 38500 saplings ha-1). When compared to the sapling density of adjacent stands, densities of post-harvesting regeneration were twice lower within strip cuts in south-facing sites, but twice higher within gaps in north-facing sites. With increasing strip width, regeneration density decreases on sites with limited water supply. Availability of dense regeneration before harvesting is essential for ensuring regeneration success of spruce in Alpine forest stands.

Picea abies, Alpine forests, regeneration success

Theme 2: Forests and Climate Change

33 - Open Session

Room "Colmar" (Novotel Freiburg)

IUFRO17-3093 **Tree range expansion in eastern North America fails to keep pace with climate warming at northern range limits**

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Abstract: Rising global temperatures are suggested to be drivers of shifts in tree species ranges. The resulting changes in community composition may negatively impact forest ecosystem function. However, long-term shifts in tree species ranges remain poorly documented. We test for shifts in the northern range limits of 16 temperate tree species in Quebec, Canada, using forest inventory data spanning three decades, 15° of longitude, and 7° of latitude. Range shifts were correlated with climate warming and dispersal traits to understand potential mechanisms underlying changes. Shifts were calculated as the change in the 95th percentile of latitudinal occurrence between two inventory periods (1970-1978, 2000-2012) and for two life stages: saplings and adults. We also examined sapling and adult range offsets within each inventory, and changes in the offset through time. Tree species ranges shifted predominantly northward, although species responses varied. As expected shifts were greater for tree saplings, 0.34 km y-1, than for adults, 0.13 km y-1. Range limits were generally further north for adults compared to saplings, but the difference diminished through time, consistent with patterns observed for range shifts within each life stage. This suggests caution should be exercised when interpreting geographic range offsets between life stages as evidence of range shifts in the absence of temporal data. Species latitudinal velocities were on average < 50% of the velocity required to equal the spatial velocity of climate change and were mostly unrelated to dispersal traits. Finally, our results add to the body of evidence suggesting tree species are mostly limited in their capacity to track climate warming, supporting concerns that warming will negatively impact the functioning of forest ecosystems.

range shifts climate change forest inventory plots

Room "Colmar" (Novotel Freiburg)

IUFRO17-1385 **Capacity of urban ecosystems in Bulgaria to mitigate climatic changes through assessment and mapping of carbon storage at national scale**

Nedkov, S. (1); Zhiyanski, M.* (2); Nikolova, M. (1); Gikov, A. (3); Nikolov, P. (1); Todorov, L. (4); Glushkova, M. (2); Sokolovska, M. (2)

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Abstract: Urban ecosystems are related to a number of benefits for the human society through the provisioning of ecosystem services (ESs) by the established green and blue infrastructure. Meanwhile urban areas are characterized by strong deviations from the natural systems in structural and functional aspects due to both anthropogenic pressure and global changes impacts. Urban ecosystems include urban and peri-urban, industrial, commercial, and transport areas, urban green areas, mines, dumping and construction sites. The accurate assessment of current state of these diverse ecosystems is fundamental for ensuring the sustainability in ESs delivery in the next decades and to answer to different stakeholders' needs. In present study the capacity of urban ecosystems to regulate climate and to mitigate climatic changes is presented based on assessment of carbon storage in different elements of the complex urban systems. The developed national methodological framework, considering the variety of sub-types of urban ecosystems and combination of relevant indicators, is applied. It was established that the spatial structure of green, blue and gray infrastructure in urban areas plays a significant role in the assessment as well as in the integration and promotion of ESs to the local contexts. The elaborated maps of the capacity of urban ecosystems to mitigate climatic changes are valuable tool for spatial planning of territories for further application of nature-based solutions.

urban ecosystems, GI, carbon storage, mapping ESs

Room "Colmar" (Novotel Freiburg)

IUFRO17-640 **Evaluating the impact of potential fires on forest carbon sequestration in the western United States**

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(1) College of Natural Resources, University of Idaho, Moscow, United States

Abstract: Wildfire performs an intrinsic function in forested ecosystems, yet in the western United States drought coupled with increased fuel loading have led to an increase in both frequency and intensity. If this trend continues there will be increased effects on ecosystem services and it could also affect our ability to meet our Intended Nationally Determined Contributions to the United Nations Framework Convention on Climate Change. We utilize the Forest Inventory and Analysis (FIA) inventory as the basis for a two-tiered approach to project future fire regimes. First, we use climatic parameters to determine the likelihood that a fire will occur. Then, we use fuel loading to determine intensity. We apply spatially explicit economic model of U.S. forest products markets which balances harvest over time with demand for logs at regional mills. The resulting modeling system captures the complex interactions between market demand, federal forest policy, and wildfire risk. We generate results for the 2015 - 2035 time period for an array of scenarios varying macroeconomic outlook, public forest harvest levels, and future climate. Maps of the spatial allocation of forest harvesting, fire occurrence, and carbon fluxes are presented at the National level and detail is given for the western US.

Climate, intensity, partial equilibrium, wildfire

Theme 2: Forests and Climate Change

33 - Open Session

Room "Colmar" (Novotel Freiburg)

IUFRO17-1515 **Quantifying forest conservation efforts in REDD+ schemes: The key role of protected areas and indigenous territories in Panama**

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(1) Forest Research Institute, INFOR, Valdivia, Chile; (2) McGill University, Montreal, Canada

Abstract: The proposal for reducing emissions from deforestation and forest degradation (REDD+) also includes conservation, sustainable management of forests, and the enhancement of forest carbon stocks in developing countries. However, demonstrating conservation efforts in developing countries with high forest cover and low deforestation rates is complex, in particular when performance-based payments are adopted.

Using Panama as a case study to analyze forest cover and assess effectiveness in avoiding deforestation, we explored the application of matching techniques, a statistical impact analysis technique, for pairing protected and indigenous territories with unprotected areas with similar landscape characteristics.

We found that tenure status of protected areas and indigenous territories (including legally established territories and claimed lands) explains a higher rate of success in avoided deforestation than other land tenure categories, when controlling for co-variate variables such as distance to roads, distance to towns, slope, and elevation. In 2008 (the last official forest cover map in the country) protected areas and indigenous territories had the highest percentage of forest cover and together they hosted 77% of Panama's total mature forest area.

Our study shows the promises of matching techniques as a potential tool for demonstrating and quantifying conservation efforts. We therefore propose that matching could be integrated to methodological approaches allowing to establish reference levels and compensating forests' protectors. Because conserving forest carbon stocks in forested areas of developing countries is an essential component of REDD+ and its future success, the discussion of our results is relevant to countries or jurisdictions with high forest cover and low deforestation rates.

Tenure, protected areas, Indigenous peoples, REDD+

Theme 2: Forests and Climate Change

51 - Forest management strategies to enhance the mitigation potential of European forests

KG I - 1010 (Uni Freiburg)

IUFRO17-2423 **A new Dynamic Life Cycle Assessment methodology to deal with biogenic carbon fluxes and temporary carbon sequestration**

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Abstract: Although LCA has been widely used for environmental impact assessment in the forest and wood sector, this tool poses several methodological problems, because it was conceived as a static, steady-state tool, where all emissions are treated identically, regardless their time of occurrence. This limitation becomes particularly relevant when long life cycles are involved. To tackle the issue we developed a new computationally efficient methodology for dynamic LCA that enables the use of both dynamic inventory and dynamic impact assessment. In our methodology the inventory is time explicit, the characterization factors can change depending on the time of emission, and the impact can be calculated for any time horizon. This methodology is conceptually transparent, easy to implement and has been developed as open-source software. In this presentation we illustrate the proposed methodology with a case study where we calculate the climate change impact for the cradle-to-grave life cycle of a wood-panel product, considering the carbon fluxes in the forest as well as the climate impact of its production, use and end use, and compare the outcomes with earlier conventional LCA approaches.

climate impact, GWP, C storage

KG I - 1010 (Uni Freiburg)

IUFRO17-3224 **Sensitivity analysis on displacement factors for wood products**

Vial, E.* (1); Cardellini, G. (2); Valada, T. (3); Cornillier, C. (4); Hurel, C. (4); Muys, B. (3); Levet, A.-L. (1); Privat, F. (5); Laret, F. (4)

(1) FCBA, Champs sur Marne, France; (2) Division Forest, Nature and Landscape, KU Leuven, Université libre de Bruxelles, LEUVEN, Belgium; (3) Division Forest, Nature and Landscape, KU Leuven, LEUVEN, Belgium; (4) FCBA, Bordeaux, France; (5) Ecole Supérieure du Bois, FCBA, Nantes, France

Abstract: Global environmental evaluations of forest management scenarios are being done at European and national level including the sink effect of the forest, carbon storage in harvested wood product and the substitution effect. The substitution effect corresponds to the difference between the fossil greenhouse gases emissions associated with wood products' life cycle and the fossil greenhouse gases emissions associated with competing products' life cycle based on functional equivalence. This effect of material substitution is often evaluated by using one displacement factor for all wood products based on the average of different studies.
In the Formit project, the displacement factors were calculated for various wood products using a consistent methodology and homogeneous data. For construction product, the framework provided by the EN 15804 standard on Environmental Product Declaration (EPD) was used to differentiate the life cycle steps when substitution can occur. However, as no EPD data could be used in the Formit project, the displacement factors were calculated based on a simplified modelling. On the other hand, it was thus possible to parametrize the Life Cycle Inventory models, perform a minimum and maximum analysis and provide country specific results.

substitution, displacement factor, wood product

KG I - 1010 (Uni Freiburg)

IUFRO17-1696 **Markets of forest products in European countries**

Levet, A.-L.* (1); Vial, E. (1); Jasinevicius, G. (2); Mues, V. (3); Mohren, F. (4); Dragoi, M. (5); Neumann, M. (6); Berninger, F. (7); Rorstad, P. K. (8); Bronisz, K. (9); Cardellini, G. (10); Svoboda, M. (11)

(1) FCBA, Champs sur Marne, France; (2) EFI, Joensuu, Finland; (3) University Hamburg, Hamburg, Germany; (4) Wageningen University, Wageningen, Netherlands; (5) USV, Suceava , Romania; (6) BOKU, Vienna, Austria; (7) UHEL, Helsinki, Finland; (8) UMB, As, Norway; (9) SGGW, Warsaw, Poland; (10) K.U. Leuven, Leuven, Belgium; (11) CZU, Prague, Czech Republic

Abstract: Considering the lack of knowledge about the end uses of forest products, this paper aims to provide an estimation of the markets for forest products and semi-finished products (sawnwood, panels) in Europe. Firstly, the apparent consumption of forest products (semi-finished products) has been calculated in each European country as well as at Europe level (EU-28 + Norway + Switzerland). This calculation is based on Faostat data. Secondly, the end uses of the semi-finished products have been quantified by using a "market approach". A questionnaire has been developed for determining the main markets of each category of semi-finished products (sawnwood coniferous, sawnwood non coniferous, particle board, OSB, MDF, plywood) in some selected European countries. In total, data from 13 countries have been collected. They represent between 70% and 80% of the European consumption. Based on these data, a weighted average of markets has been calculated for each European FORMIT region (Northern, Central-West etc.) as well as at Europe level. Finally, the scheme of flows from the forest resource to the semi-finished products and the final markets (construction, packaging, furniture etc.) is presented at Europe level.

forest products, markets, European countries

Theme 2: Forests and Climate Change

51 - Forest management strategies to enhance the mitigation potential of European forests

KG I - 1010 (Uni Freiburg)

IUFRO17-2320 **Harvest and carbon leakages of large harvest reductions in Europe**

Solberg, B.* (1); Moiseyev, A. (1)

(1) Norwegian University of Life Sciences, Aas, Norway

Abstract: In FORMIT's Biodiversity & Conservation scenario (BioDiv) the European harvests is strongly reduced, and in this presentation we assess how much the harvest in rest of the world (RoW) will increase because of that reduction, thus quantifying the so-called harvest leakage and getting a basis for discussing the carbon leakage impacts of this scenario. Applying the global spatial partial equilibrium model EFI-GTM in combination with the FORMIT forest growth model, we analyze the differences in market impacts between a predefined Business as usual scenario (BAU) and BioDiv, assuming that the global demand for forest industry products are the same in the two scenarios. The results suggest that annually 75-100% of the harvest reductions that would take place in the EU in BioDiv relative to BAU, would be offset by an opposite change in RoW during the period 2015-2100. The corresponding carbon leakage is likely to be higher as the forest industries in Europe are at least as energy efficient or based on less usage of fossil fuel than similar productions in RoW. These leakage impacts are important to consider when estimating global climate mitigation effects of harvest changes in Europe.

Timber supply, climate mitigation impacts, trade

KG I - 1010 (Uni Freiburg)

IUFRO17-2372 **Economics of forest management for carbon storage and mitigation**

Rørstad, P. K.* (1); Moiseyev, A. (1); Solberg, B. (1)

(1) Faculty of Env. Sci. and Nat. Res. Man., Norwegian University of Life Sciences, Ås, Norway

Abstract: In the EU-FORMIT project we assessed the effects on forest owner income and the forest sector in general from proposed changes in management. This was done by utilizing results from a questionnaire assessing costs and benefits of different forest management systems in combination with results from simulations with the partial equilibrium forest sector model EFI-GTM for the period 2010 - 2100.
Through the questionnaire we collected data for almost 160 "forest units" (combination of country, main management strategy and species group). As expected, the questionnaire revealed large differences between different management and species combinations, as well as large differences between countries. We found no clear patterns regarding average costs and income at regional level.
Three scenarios were run with the EFI-GTM model in concert with the FORMIT forest growth simulator: business as usual (BAU), focus on biodiversity and conservation (BioDiv) and maximum bioenergy (MaxBio). The results indicate that the average timber price at plant gate will increase under BAU and MaxBio, while under the BioDiv scenario timber prices are decreasing in the long term after a sharp increase initially. In all three scenarios, the average timber price is significantly lower in the South East than in the other four FORMIT regions. Simulating timber markets 90 year into the future clearly entails large uncertainties that the reader should acknowledge.

climate mitigation, forest income, EFI-GTM, FORMIT

KG I - 1010 (Uni Freiburg)

IUFRO17-1918 **FORMIT Integrated evaluation of forest management impact simulations on carbon stocks and socio economic and environmental attributes of European forests**

Mues, V.* (1); Härkönen, S. (2); Moisejev, A. (3); Cardellini, G. (4); Vial, E. (5); Moreno, A. (6); Neumann, M. (6); Vlad Strimbu Olschofsky, K. (1); Rorstad, P. K. (3); Valada, T. (7); Chirici, G. (8); Goudiaby, V. (9); Bronisz, K. (10); Trotsiuk, V. (11); Svoboda, M. (11); Dragoi, M. (12); Lang, M. (13); Thivolle-Cazat, A. (14); Hasenauer, H. (6); Zasada, M. (15); Solberg, B. (3); Muys, B. (7); Mäkelä, A. (2); Köhl, M. (1); Mohren, G. M.J. (9)

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Abstract: The bioeconomy is going to increase the demand for European forest biomass while society will demand contribution to climate change mitigation and other socio-economic and environmental functions. These potentially competing demands render tradeoffs necessary between current and future operational, protective and recreational functions of the European forests. The FORMIT project aimed at developing forest management scenarios that allow for the evaluation of such trade-offs.
A climate-sensitive, semi-empirical forest growth simulator was used to quantify on basis of forest inventory data the future development of forest carbon stocks and the provision of harvested wood. Socio-economic and environmental attributes were elaborated by means of economic models and life cycle assessments. A European wide information layer on forest units was used to transfer the simulation results to five European regions: north, central-east, central-west, south-east and south-west Europe.
We simulated forest management scenarios in two different ways. First, the three FORMIT scenarios "Business-as-usual", "Bioenergy" and "Biodiversity" were run iteratively with the FORMIT growth simulator and EFI-GTM. This is to insure a balance between supply and demand of harvested wood. Following the second way, merely forest management driven scenario runs revealed the potential supply of harvested wood with respect to the maximum biological potential. These two approaches allowed for a holistic evaluation of European forests' potential contribution to climate change mitigation and the future provision of forest functions.

forest management, mitigation, scenario analysis

Theme 3: Forests and Forest-Based Products for a Greener Future

95 - Forestry classic´ for the future

KG I - 1224 (Uni Freiburg)

IUFRO17-2300 **Resource efficient and cascade use of wood - a challenge for raw material research**

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Abstract: Cascading use of biomass, such as wood and agricultural products, means an efficient use of these resources. The principle of cascading use gives a priority to higher value uses, which also allow the reuse and recycling of products and raw materials and promotes energy use only when other options are not feasible.

Biomass should be used for high value purposes before energy use since burning implies the raw material being lost. This is often the case with side streams such as bark and residues. Resource efficient use also favors energy production combined with 'co-products' such as biochemicals or nutrients. Cascading use is not limited to mean only the recycling of raw materials. In line with the idea of the circular economy, maintenance and reuse of products needs to be considered also in the case of biobased products.

Norway spruce and Silver birch are important tree species in Nordic forestry and their bark contains valuable compounds. However, the bark is mainly used for energy production. Part of this important side product is possible to use to improve properties of wood and fibre based products and thus, promote the cascading use of them. For example, birch bark contains suberin which could used to create hydrophobic and antimicrobial surfaces.

Tannin and lignin based adhesives from Norway spruce bark could be also used to replace chemicals causing harmful emissions which lower indoor air quality. Wood based building materials which contain toxic chemicals are not suitable for composting purposes and limit the cascade use. There is a demand for competitive and cost-effective substitutes. Examples how research may promote the resource efficient and cascade use of wood will be discussed.

resource efficiency, wood, bark, side streams

KG I - 1224 (Uni Freiburg)

IUFRO17-1868 **Permanent research plots - new conclusions from old thinning experiments**

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Abstract: In the 60s and 70s of the former century in central and eastern part of Poland the series of thinning experimental plots according to random block system were established. The goal of the study was to find an optimal thinning intensity to maximize the volume production of Scots pine, the most important species of Polish forests.
After half of century, most of these plots still exists on ground and consecutive measurements are being performed on them. Results obtained on this base bring an important information about competition between trees under different thinning regimes, resistance of forest ecosystem against atmospheric and biotic factors and processes of conversion from one-species stand to mixed one.
The last cycle of measurements has been performed in years 2015-2016 on the experimental plots in six forest districts. Stand basal area, mean and dominant height, basal area, current increment and competition indices of future crop trees were calculated. The threat of fungi diseases and insect gradation was evaluated.
Results show that first thinning intervention is of a high importance for the stand structure and its future growth but the consecutive tending have a strong influence of its stability against biotic and abiotic factors. Thinning negligence has an negative impact on stand resistance but too strong interventions may cause equally high risk in some situations.

thinning,Scots pine,increment,fungi,insects

KG I - 1224 (Uni Freiburg)

IUFRO17-242 **The earliest research of tending felling established according to Junfo system in North-West Russia**

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Abstract: Research facilities on tendingfelling for forests in North-West Russia were established during 1929-1930 according to technique accepted by the II World Forestry Congress in 1928 in Rome. The purpose of this work originally consisted in clarification of effectiveness of this forestry measures, degree of its influence on an increase for weight, height, and also on quality of timber. This necessity was caused by the fact that it was the first such experience at that time. The main objective consisted in specification of intensity and techniques of tending felling. Now data on qualitative and quantitative characteristics of spruce timber and trade structureatfacilities passed through by stands tending felling are obtained. Outside influence in the form of tending fellingcauses change of current increase fluctuations nature in spruce stands. There are structural changes in elevated and underground plants biomassin a stand. The ratio between the stem, crown and underground plants biomass of a stand changes in favour of the last two. Now the high-performance spruce plantings with a wood density surpassing the average values for the region grow on research facilities. On all research facilitiestheappearance of fir-tree advance growth is noted. The tending felling can affect on the course of natural reforestation and does not cause fundamental change in the ratio between a grass and moss layers. They shift this ratio in favour of the first oneand it allows claiming about the possibility of biocirculation intensity increase by means of regular tending felling of the forest. Now it is the most valuable research facility allowing coming to scientifically substantiated conclusionson expediency of one or another techniques of tending felling which correspond to exact combination the silviculturaland economic requirements for forest management.

tending felling, spruce stands

Theme 3: Forests and Forest-Based Products for a Greener Future

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Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2942 **Effects of tree diversity on productivity and stability in Short Rotation Coppice (ECOLINK-Salix)**

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Abstract: Short rotation coppice (SRC) plantations have a high potential for biomass production. They are often managed as monocultures, however, mixed communities may have higher productivity and stability in comparison to monocultures. Yet little is known about diversity effects in these production systems. Understanding these effects may thus help to produce biomass in a more sustainable way. The aim of our project is to investigate the effect of increasing tree diversity on a number of ecosystem processes in SRC plantations. To this end, we have established three SRC plantations with four Salix genotypes grown in monoculture and in 2-, 3-, and 4- mixture, one in Sweden and two in Germany in 2014. In these trials, we investigate how genetic diversity influences: 1) above ground biomass production; 2) below ground resource use complementarity; and 3) nutrient retention in biomass and in soil. The ultimate goal is to understand the underlying mechanisms of tree diversity effects on productivity and ecosystem functioning, specifically, if observed differences are due to complementarity for resources. In the presentation we will discuss first results regarding the effects of increased genotype diversity on the above ground biomass productivity after three years of growth in three trials located in Uppsala (Sweden), Rostock and Freiburg (Germany).

biodiversity, biomass, genotype

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3567 **Future foresight for the forest sector**

Vanclay, J.* (1)

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Abstract: Presents the findings of the IUFRO Taskforce on Forest Foresight. While there is widespread in-principle support for foresight to support informed forest management, closer investigation reveals reluctance to engage in foresight activities. This reluctance appears to be related to political correctness, to insecurity, and to uncertainity about how controversial findings will be received. Taskforce member report n their experiences, offering insights about how to engage potential participants in the process, about how to conduct a foresight exercise for maximum impact, how to interpret the findings, and how to use te findings to plan a course of action.

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2973 **Life-cycle Assessment of Wood Products from Natural Tropical Forests in Costa Rica**

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Abstract: The contribution of forest management and harvested wood products for climate change mitigation have been demonstrated to provide a certain level of emission reductions and for this reason have been included within the reporting framework of some countries under the UNFCCC. However, most of the evidence points out to a rather small contribution. As a result, the forest sector now claims that the real benefits from wood product use is their lower carbon footprint compared to other more carbon intensive products. In order to provide evidence for these substitution effects, wood products and their production chain need to be studied following a life cycle approach comparable with that from other substitute products. This work shows the results from a lifecycle assessment conducted for wood products from natural forest management in Costa Rica. Through this lifecycle assessment, we are able to determine the climate impact of these activities and provide evidence for potential substitution effects associated to wood product use in the tropics. By doing so, we highlight the need for some tropical countries to advance the discussion around forests and deforestation and degradation, and consider opportunities for climate change mitigation along with other co-benefits that may be found through forest management.

tropical forests lca wood products substitution

Theme 3: Forests and Forest-Based Products for a Greener Future

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Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2277 **Reproductive phenology of pure and mixed Nothofagus forests of southern Patagonia**

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Abstract: Reproductive success (flowering, seeding and seedling) is a paramount process for tree regeneration and forest ecosystem conservation and management. In mixed forests, the impact of limiting (biotic and abiotic) factors on tree reproductive success regulates the maintenance of species in balanced proportions, or the conversion towards monospecific forests. We assessed tree reproductive phenology and success in pure deciduous *Notofagus pumilio* (Np), pure evergreen *Nothofagus betuloides* (Nb), and compared it with mixed (M) forests, considering two geographical location (coast and mountain), during three years. Also we evaluated the incidence of different loss factors (e.g., premature abortion, fruit and seed predation). Both deciduous and evergreen species have reproductive advantages in M compared to pure forests: (i) less abortions (flowers and fruits) of Nb in M than in pure forests (ii) M had twice male flowers of Nb than in the pure forests. Seed production was highly variable for both tree species in all sites. However, M was more similar to pure evergreen forests in their reproductive traits (e.g., amount of seed fall) as the potential seed production (number of possible propagules including lost structures) was more similar between Nb and M. The main limiting factor was female flowers deriving in empty seeds for all forest types. We detected a strong effect of geographical location on seed production as well as on the losses factors during flowering and seeding stages. However, Np was less responsive to geographical locations, while the marine climate seems to be more favourable for Nb. This study contributes to understanding of the possible roles of reproductive phenology for detecting shifts in forest communities between pure and mixed forests under natural dynamics and the current climate regime.

Natural dynamic, forests, geographical location

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-932 **Continuous cover forestry as a cost-efficient tool to increase multifunctionality of boreal production forests**

Peura, M.* (1); Burgas, D. (1); Eyvindson, K. (1); Mönkkönen, M. (1)

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Abstract: Diversifying silvicultural practices may be a cost-efficient tool to ensure multifunctionality in production forests. Our study compared the effects of continuous cover forestry and conventional rotation forestry on provisioning, regulating and cultural services as well as on biodiversity indicators and landscape multifunctionality in boreal forests in Finland. We simulated slightly over 30,000 of commercial forest stands for 100 years under continuous cover and rotation forest managements. To estimate the relative performance of practices, unmanaged forests were used as a benchmark. Results revealed that continuous cover forestry was better than rotation forestry for 5 of 8 ecosystem services and for 6 of 8 biodiversity indicators. Multifunctionality was higher in continuous cover forests having a greater potential to produce simultaneously multiple benefits. Nevertheless, the combination of these two silvicultural practices provided higher values of different objectives than consistent application of either of the practices highlighting the role of landscape level planning. Moreover, unmanaged forests often provided the highest levels of services and biodiversity making their role indispensable. Continuous cover forestry does not itself resolve the problem of the decline of all ecosystem services and biodiversity in production forests but it can be an essential part of the solution towards more sustainable forestry.

uneven-age, multiple benefits, sustainability

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2093 **Silvicultural management options in Alaska forests to increase forest biodiversity and enhance ecosystem services**

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Abstract: Worldwide, there is increasing interest in managing forests to maintain or improve biodiversity, enhance ecosystem services and assure long-term sustainability of forest resources. Old growth, Sitka spruce/western hemlock forests of southeast Alaska have relatively simple species composition but complex stand structures with high diversity of tree ages and forest canopy levels, and an abundant understory plant community. As a result of forest management, the even-aged, pure conifer stands that succeeded following clearcutting old growth forests, developed less diverse stand structures and provided reduced wildlife habitat. New silvicultural systems that use partial cutting in older mixed conifer forests could alleviate some of the problems associated with conventional even-aged management and increase both stand structural diversity and biodiversity. Here we synthesize information on management options in younger forests and provide strategies for increasing stand structure diversity, associated effects on biodiversity, and the provision of important ecosystem services. One important strategy is the inclusion of red alder in young, conifer-dominated forests that develop after clearcutting. Results indicate that mixed red alder-conifer stands provide more heterogeneous structures, significantly higher understory biomass and deliver a wider range of ecosystem services.

ecosystem services, red alder, Sitka spruce,

Theme 3: Forests and Forest-Based Products for a Greener Future

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Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3863 **Studies on the durability of several tropical wood species**

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Abstract: The sawdust of wood species, mainly from Congo basin, was studied to assess their natural resistance to decay in order to evaluate the potential valorization of their extractives The contents in extractives and lignin were determined to get an insight of the chemical distribution. Then, phytochemical screening by colorimetric methods, antioxidant activity and total phenolic content determination were performed. The resistance to decay of extracted and unextracted sawdust against white-rot fungi was evaluated
Presence of tannins and flavonoids was detected in variable quantities in different wood species. Saponins were detected in several species (tali, okan, bilinga and moabi) while alkaloids were only present in tali. Antioxidant properties were related to phenolic content with some modulation according to the nature of phenolic compounds. The development of mycelium was strongly dependent on the presence of extractives: wood species with high extractive contents were generally poorly colonized by the fungal strains. Wood species with low extractive content were usually colonized by fungi.
All the properties determined in this study constituted evidences of durability. However, some exceptions indicated that a deeper investigation was necessary to understand completely the relationship between wood durability and wood extracts chemical compounds and to consider their industrial uses.

wood durability,extractives,antifungal,antioxidant

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1006 **Presence of anti-fungal sapwood and heartwood extractives of selected decay resistant and decay susceptible Malaysian hardwoods and Scots pine (Pinus sylvestris)**

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Abstract: A general laboratory bioassay method of Woodward and Pearce (1985) was adopted to detect antifungal activity of sapwood or heartwood extractives of 5 Malaysian hardwoods [dark red meranti heartwood (Shorea spp.), red balau heartwood (Shorea spp.), kulim heartwood (Scorodocarpus borneensis), jelutong sapwood (Dyera costulata) and rubberwood sapwood (Hevea brasiliensis), including the temperate Pinus sylvestris (Scots pine sapwood). The heartwoods of these species are known to be highly resistant to decay by soft-rotting Ascomycetes and Deuteromycetes (about 1% wood mass loss), while the sapwoods of rubberwood, jelutong and Scots pine had much reduced soft rot resistance, respectively 35, 32 and 7% wood mass loss. Crude methanol extracts of woodmeal samples of each wood species were loaded on to thin-layer chromatography plates at between 0.003 and 0.1 g fresh mass equivalent of woodmeal per spot so as to optimize resolution of separated compounds,. and developed with chloroform:methanol solvent (ratio 19:1). The dried plates were sprayed with fresh fungal spores of Cladosporium cucumerinum and incubated at >90% RH for 5 days in the dark. Presence of antifungal compounds was revealed by white regions along the solvent transect for each extract of each species where inhibited spore germination and mycelial growth of C. cucumerinum occurred. Comparisons of extracts between species and between sapwood and heartwood were noted. Results revealed that several zones of inhibitory activity, indicated by their Rf-values, were clearly visible on chromatographic separations of methanol extracts of these 5 wood species. The inhibitory zones for 2 heartwood extracts (except kulim) did not move from the origin which was also resistant to infection. However inhibition zones were also detected for the sapwoods of rubberwood, jelutong and Scots pine at least against C. cucumerinum which may elicit transitory resistance of the sapwood to fungal infection and onset of decay.

Antifungal, wood extractives, soft rot decay

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-703 **Fungal glutathione transferases and wood extractives**

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Abstract: Extractives are molecules that represent a minor fraction in wood. However, they are source of diverse putative bioactive molecules. Among the properties of wood extractives, inhibition of fungal growth is one of the most interesting in a context of wood preservation, crop protection or medical treatments. Lignolytic fungi, which are adapted microorganisms to wood substrates, have developed various strategies to protect themselves against this toxicity. The adaptation of these organisms to their life style is due at least in part of the existence of extracellular degrading systems. Besides these extensively studied extracellular systems of degradation, wood decaying (and more globally complex organic matter degrading) fungi possess also extended detoxification systems in comparison with other fungi belonging to other trophic types. A comparative genomic approach revealed indeed the presence of an extended multigenic family encoding glutathione transferases (GSTs) in the genomes of wood decayers. A phylogenetic analysis revealed that this extension concerns at least four classes of GSTs (omega, FuA, Ure2p and GTT), these extended classes varying in function of the considered fungus. During the last few years, our group has strongly invested in the biochemical and structural characterization of various isoforms from different fungal models and in particular from Phanerochaete chrysosporium. The characterized isoforms are also able to interact with various molecules present in wood from various tree species , such as flavonoids , terpenes or products resulting of the wood biodegradation From these structural and biochemical studies, we will discuss the physiological functions of the interactions between this multigenic family of GSTs and wood extractives.

wood extractives, fungi, glutathione transferases

Theme 3: Forests and Forest-Based Products for a Greener Future

82 - Traditional coppice: ecology, silviculture and socio-economic aspects

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1041 **Traditional Coppice Management - Legacy and Potential: Findings and Conclusions of the European COST Network 'EuroCoppice'**

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Abstract: Coppice management has played a major role in forest utilisation for millennia, especially in supporting the livelihoods of rural community members. The past century, however, has seen a shift away from this practice, as well as relative neglect in forest research. So where are we now and what does the future hold for the oldest form of systematic and sustainable forest management?

This presentation outlines the current status of traditional coppice management (TCM) in Europe, including an overview of geographical distribution, utilization and the related ecosystem services. The influence of the economic and political framework conditions on TCM are analysed. Conclusions from this situation will be drawn and used to illustrate future scenarios. The hypotheses and data of the presentation will be supported by results from the COST Action FP1301 EuroCoppice. In September 2017, this EU-funded network of more than 35 partner institutions will come to an end after four years of European-focussed international scientific collaboration on a wide range of coppice-related topics. (www.eurocoppice.uni-freiburg.de)

coppice utilisation & services, COST EuroCoppice

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IUFRO17-477 **Terminology and multilingual glossary on Coppice terms**

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Abstract: In the framework of the European COST action "EuroCoppice" (FP1301) a working group on terminology was started. During the four years of the project Coppice related terms in the widest sense of the word were collected from literature, forest dictionaries, encyclopedia and from publications by the other four working groups.
These terms were then defined in English, preferably based on existing sources, but otherwise by the participants of the working group. A typology for the different types of coppice was made as well and illustrated to make the meaning clear.
Once this list was composed, it was sent out to all the 39 member countries of this COST action at first to check if everyone agreed to the definitions. After acceptance, the list was updated and then sent for translation into the national languageof that particular country with a small programme The programme automatically transposed the translation into Unicode, where each character has a number, even the curious characters that are used in nearly each country. By translating into Unicode, it was made easy to join all the translations into a single database.
This multilingual database existed from a previous COST action (FP 0902), which focused on terms on wood harvesting and the energetic use, which now has been widened to include the coppice related terms. The database also contains illustrations of many of the terms.
The database allows translation from any of the included languages to any of the others. The database is freely accessible through the EuroCoppice homepage.

coppice multilingual glossary, terms, definitions

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IUFRO17-93 **Harvesting of traditional coppice stands: results from 40 years of European research**

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Abstract: Operating within the scope of COST Action FP1301 "Eurocoppice", the Authors conducted a survey of coppice harvesting studies produced in Europe from 1970 to present. The survey focused on traditional coppice stands and excluded industrial short-rotation coppice. The goals were to calculate productivity benchmarks for coppice harvesting operations, and to gauge the progress achieved over the past 40-plus years. 377 data points were gathered from 102 studies, both published and unpublished. Six productivity models were estimated for the main harvesting steps and technologies. Productivity varied with a number of factors, and notably with removal (m3 ha-1). The analysis disclosed a clear trend towards increased mechanization and higher productivity. Coppice harvesting is being mechanized, but the mechanization deployed in coppice stands is adapted to the specific conditions offered by these stands. Light, cheap and versatile machines are generally preferred to heavy industrial equipment. Versatile general-purpose machines (excavators and farm tractors) still represent the backbone of coppice mechanization, which is consistent with the rural character of coppice economy. The study offers valuable benchmark figures about coppice harvesting performance, that may help directing decision-makers when trying to modernize coppice management and increase its competitive capacity.

logging; productivity; efficiency; meta-analysis

Theme 3: Forests and Forest-Based Products for a Greener Future

82 - Traditional coppice: ecology, silviculture and socio-economic aspects

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1742 **Factors affecting biomass and wood extraction from coppices in Europe: Productivity models and influence of technological changes.**

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Abstract: Productivity (m3/effective machine hour) in mechanized extraction of firewood, logs, stems or whole trees from traditional coppice forests (Quercus species, beech and chestnut) has been analyzed using data from 128 studies performed between 1973 and 2015 in Italy (99), Spain (24) and the U.K. (5). Significant differences among clearcut and selective felling productivity has not been found. Neither harvesting systems (CTL, WTS, Full Stem) have shown to mark significant differences regarding productivity, possibly because of the wide variety of extraction means and extracted products. However, a common productivity model was fitted for skidding, forwarding and yarding (considered in a wide sense, by very different machine types), by using a nonlinear regression with explanative variables maximum extraction distance (m), machine payload (m3) and felling intensity (m3/ha). The regression equation had an adjusted R2 = 65% and an average absolute value for residuals of 1,2 m3/h. Besides, particularized productivity equations were fitted for skidding and yarding, with lower average absolute value for residuals. Finally, productivity and its relationship with the explanative variables have been compared between studies from the last decade and former ones. A significant increment of productivity for the same values of these factors has been found, probably due to the technological improvements of the mechanized extraction means used in recent times.

traditional coppice,hauling off,mechanization

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IUFRO17-100 **The impact of mechanized cutting on coppice mortality, re-sprouting vigor and physiology**

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Abstract: Coppice harvesting must be mechanized in order to reduce work accidents and production costs, as well. However, foresters are concerned that mechanized cutting may cause severe stump damage, which would result in increased mortality and lower growth rates. The study compared manual and mechanized cutting in terms of cut quality, stump damage levels, stump mortality, re-sprouting vigour and shoot growth. The study was conducted in a classic Mediterranean coppice stand located in central Italy. The oak-dominated coppice was cut using a chainsaw (control), a disc saw and a shear. The experiment adopted a split-plot design, based on 5 plots divided into 15 subplots (one subplot per plot and technology). Overall, 344 stumps were selected, tagged and monitored over the first growing season after cutting. Stump size, cutting height and cutting damage were determined right after cutting. At the end of the first growing season the following parameters were also recorded: n° of shoots; height, diameter and type of the tallest 5 shoots. Samples were collected from randomly selected stumps during the main phenologic phases in order to determine the content of C, N, starch and soluble sugar, as well as the C:N ratio. Mortality was limited and ranged from 4 to 8%. Re-sprouting was generally vigorous, and dominant shoots often exceeded the height of 1.5 m after one year. Cutting technology had a significant effect on cutting height and cutting damage, but it had no effect on mortality, re-sprouting vigor and nutrient balance within the stumps, at least in the first growing season. In contrast, regeneration vigor was found to depend mainly on species. While it may result in higher stump damage levels, mechanized cutting does not seem to have any effects on coppice regeneration and growth, at least in the first year. Previous studies indicate that effects recorded during the first growing seasons may be representative of longer-term trends.

felling; regeneration; growth; mortality; CN ratio

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1099 **Coppice conversion, a difficult and long-lasting process in Europe**

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Abstract: Coppice forests, dominated by broad-leaved tree species such as oaks (Quercus spp.) and beech (Fagus spp.), and producing especially small-sized timber for energetic uses, are an important component of European rural areas. Under the pressure to produce large-diameter logs for industrial uses, the process of converting coppice forests to high forest has started in Europe in the first half of 19th century. Since then, different methods of coppice conversion (i.e. direct vs. indirect, by ageing, substitution, reconstruction, etc.) have been developed and used in similar ways Europe-wide in order to enhance the ecological, commercial and social values of coppice forests.

Currently, the conversion of coppice forests comprises especially those coppices showing various degrees of degradation (e.g., with inappropriate species composition, under-stocked, low productive, with rotten stumps, etc.). In case of privately-owned coppices, this process is driven by either legal requirements (forest laws) or financial incentives such as the EU subsidies for rural development. In this context, taking into account the revival of coppice forests as the result of increasing use of renewable sources of energy in the rural areas, the paper presents some case-studies of coppice conversion in the south-east of Europe.

coppice, conversion, rural areas, forest policy

Theme 3: Forests and Forest-Based Products for a Greener Future

82 - Traditional coppice: ecology, silviculture and socio-economic aspects

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1845 **Natural seed regeneration in chestnut coppices: a key factor in planning silvicultural management.**

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Abstract: Over the last 50 years, many unfavourable factors have led to the abandonment of the traditional management of many chestnut coppices. This generated a general aging of the stands and a related reduction of the slope stability, emphasizing the importance of natural regeneration for future forest management.
Natural regeneration from seed contributes to the increase of the stem density, provides new stools for future coppice generations and promotes the proper development of the stand in terms of specific and structural diversity.
In this study we tested the effect of different silvicultural treatments in coppice stands on the seed regeneration potential of the chestnut tree. The chestnut seed regeneration resulted to be influenced by: I) the age of the stand at felling time (increasing age was related to a greater presence of regeneration from seed), II) the cover of released over-aged trees (light conditions on the soil), III) microclimatic conditions (drought stress in particular).
Overall, the natural regeneration dynamics in chestnut coppices revealed to be a useful reference to identify some general guidelines for sustainable interventions aiming to foster chestnut regeneration, while maintaining biodiversity in an effort to improve the quality of timber assortments.

castanea sativa, coppice, natural regeneration

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1531 **Coppicing restoration in two contrasting land use situations: effects on biodiversity of vascular plants and invertebrates**

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Abstract: Reintroduction of traditional coppicing aims at restoration of declining biodiversity in European woodlands. However, coppicing restoration faces several challenges. The former land use can be an important factor driving the trajectories of development in restored biotic communities. Our aim was to explore the effect of coppicing restoration on taxonomic and functional diversity of vascular plants and ground invertebrates in two contrasting land use situations. We used functional traits to describe the mechanisms driving the community assembly, which helped us to understand the effects of the past land use.
We chose two forests in southern Moravia, Czech Republic. One site is an ancient forest with long coppicing history, which has been interrupted for seven decades and reintroduced in 2009. Another site is a secondary forest planted after the WWII and coppiced in 2012. We found that the forest continuity dramatically influenced community composition and conservation status. In the ancient forest, populations of local species including target species of nature conservation thrived. In the secondary forest, fast establishment of annual species migrating from the surrounding agricultural landscape occurred, yet no forest species established after five years. We concluded that forest continuity plays a crucial role in biodiversity restoration in traditional coppices.

functional traits, biodiversity, land use

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-3117 **Restoration of coppice-with-standards management : effects on ground vegetation and bryophytes.**

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Abstract: Traditional coppice is often highly appreciated in nature conservation, as its cyclic alternation of open and dense forest stands promotes both light-demanding and shade-tolerant species. When abandoned, many associated light-demanding species may decline and even disappear. Conservation and restoration of coppice-with-standards management is therefore often advocated and applied in conservation areas.
Like many forests in North-Western Europe, the Meerdaal forest (Central Belgium) was managed for centuries as coppice-with-standards, but over the last 60-70 years, gradually converted to high forest. On an area of 20 ha, an experimental restoration of coppice-with-standards was initiated about 10 years ago. At this moment, the different successional stages of a coppice-with-standards (cut open area, reclosing coppice, and uncut areas) are available
A 'place-for-time substitute - chronosequence experiment was set up, in order to study the effects over time on ground vegetation and bryophytes. First results indicate a peak of light-demanding competitive and ruderal species immediately after the cut. After one decade however a decline of typical shade-tolerant ancient woodland species -especially bryophytes- is still apparent and is not compensated by targeted light-demanding species. Aspects of nutrient accumulation, competition, and dispersal capacity may help to explain these results.

coppice-with-standards, bryophytes, vegetation

Theme 3: Forests and Forest-Based Products for a Greener Future

82 - Traditional coppice: ecology, silviculture and socio-economic aspects

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1394 **Effect of tree age and stump height on initial Nothofagus antarctica stump sprouting in Chilean Patagonia**

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Abstract: Nothofagus antarctica forests in Chilean Patagonia have undergone a process of degradation because of over exploitation for fuelwood collection, over grazing practices and uncontrolled fires. Stump sprouting is an important reproduction mechanism in for N. antarctica; however, there is scarce information about factors that affects resprouting availability. For other species, it has been documented that the age of the trees and the stump height are two factors that can influence the performace of the sprouts. The objective is to assess stump mortality and re-sprouting intensity in relation to vitality of parent trees, stump parameters and three stump height (stumps cut close to the soil, with 30 cm and 130 cm tall), in two contrasting landscapes.Two degraded forests were selected in the Supratemperate bioclimatic zone, with different macro-bioclimate respect to rainfall regime: Perhumid in Valle California (~2.250 mm year-1, 43 º40'S, 71º43'W, 670 m asl) and Humid in Balmaceda (~570 mm year-1, 45º50'S, 71º47'W, 615 m asl). In summer 2015, trees were cut at three heights: close to the soil (CS, 41 trees), 30 cm aboveground (30cm, 41 trees) and 130 cm aboveground (130cm, 40 trees). Parent trees were between 12 and 89 years old. Between 60 and 90% of stumps sprouted. In average the number of sprouts by stump is statistically lower in CS respect to others stump heights. Maximum sprout height is not affected by stump height. With stumps cut 130 cm height, the height of sprouts shows a possitive correlation with age of parent trees. The results show a differential response in re-sprouting ability respect to position in the landscape, being higher in Valle California (place with higher rainfall amount). At higher cutting height there would be a greater number of resprouts and heights. In general, the age of the trees does not show clear evidence of influence on the capacity of vegetative regeneration.

Ñirre, sprouting, stump height, Chile

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-2802 **The drivers of tree productivity in newly restored coppices: effects of tree size, competition and diversity**

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Abstract: The productivity of coppiced trees depends on their ability to produce new sprouts after harvesting and on the consequent sprout growth. The understanding of both resprouting success and sprout growth is also a key for successful coppice restoration and management but there is still little empirical information on this issue. To address this gap, we studied development of approximately 4000 spatially mapped trees in mature sessile oak (Quercus petraea) dominated forest stands in the Czech Republic one year before and for subsequent 7 years after their harvest. The resprouting success and sprout growth were modelled as a function of both pre- and post-harvest tree size, competition, diversity and distance to a nearest standard (uncut trees) in four most common species. On average, 76% of harvested trees resprouted and survived for the following 7 years. The resprouting success was negatively affected by pre-harvest tree size but positively influenced by pre-harvest competition. On the other hand, pre-harvest tree size and diversity increased whereas post-harvest competition and standards decreased sprout growth. It is evident that the pre-harvest forest structure, competition and diversity influence post-harvest productivity of coppiced trees. Our results also suggest that in early stage of coppice development, silvicultural measures aimed to reduce sprout competition and to diversify coppiced tree species may benefit future woody biomass production.

coppice, productivity, competition, tree diversity

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-2399 **The potential barriers to persistence and development of small scale coppice forest management in Europe.**

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Abstract: This paper is based on original research into the factors influencing coppice management in seven countries carried out during the COST Action FP 1301 EuroCoppice: Innovative management and multifunctional utilization of traditional coppice forests - an answer to future ecological, economic and social challenges in the European forestry sector. This research revealed national contrasts with coppice highly valued, commercially and for ecosystem services, in some countries while there is a policy of conversion to high forest in others. While inventories of forest area are the norm the recording of coppice varies considerably; it is not always recorded separately from the overall resource. Not all policy documents mention coppice, although it is implicit in references to sustainable forest management. Factors influencing the persistence of coppice as a viable management practice and barriers to development are explored. The perspectives of different stakeholders, owners, workforce, and end users, are considered as well as supply chain and market factors. Potential interventions are evaluated to assess effectiveness in different legislative contexts. This enables an integrated perspective to be formulated on the future ecological, economic and social challenges for the European forest sector, with recommendations for future policy.

policy development intervention ecosystem services

Theme 3: Forests and Forest-Based Products for a Greener Future

82 - Traditional coppice: ecology, silviculture and socio-economic aspects

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-2858 **Legislative framework for coppice silviculture in Italy**

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Abstract: Coppice forests in Italy account for the 35% of the national forest cover, providing 66% of the country's annual wood production. Fuel-wood demand is increasing since the mid-1970s and is mainly satisfied by imports. At the same time, the demand for the wealth of ecosystem services and derived goods and benefits provided by coppice forests is growing too, following commitments to EU policies. The country's legislative framework related to coppice silvicultural systems was examined to assess the potential and any weaknesses of existing administrative procedures and technical prescriptions towards implementing appropriate management practices at forest and landscape levels. Responsibility for forest regulation nowadays is mainly delegated to Italy's 20 administrative regions (NUTS-2), five of which have the power of autonomy granted by special statutes. A large body of legislative acts at regional level are in force, besides existing laws and technical forestry prescriptions enforced both at the national and the province (NUTS-3) levels. A limited number of regions endorse procedures for a logical hierarchy in forest planning. Technical prescriptions for coppice silviculture (e.g., number of standards, rotation length) greatly differ by forest type across the country. In the majority of regions ad hoc regulations concerning nature conservation dictate additional prescriptions (e.g., coupe size and spatial arrangement, dead wood retention).

ES, planning, landscape, regulations, silviculture

Theme 3: Forests and Forest-Based Products for a Greener Future

105 - Sustainable co-production of wood and non-wood forest products

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2209 **Scientific, technical and social challenges in compatible use of multipurpose native tree species in Northeast China**

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Abstract: The forest area and growing stock volume in forest region of Northeast China occupies 24.2% and 24.9% of those in China respectively. In about 30 arbor tree species and 130 shrub species natively distributed in this region, several widely distributed and abundant stockpiled arbor tree species have economically important multipurpose functions and have the compatible utilization potential for large-scale and industrial development. For instance, Korean pine (Pinus koraiensis) is the most excellent timber species in east Asia and the very important edible pine nut production species in the world, and also can produce medically used pine needle product and polyphenols, industrial raw materials like turpentine and rosin; others like Manchurian walnut (Juglans mandshurica) Mongolian oak (Quercus mongolica), mono maple (Acer mono), Manchurian lilac (Syringa reticulata var. mandshurica), etc.. There are many problems existed in their silviculture and utilization that inhibited the development of industrialization of these tree species, such as seriously destroyed natural resources and no sufficient artificial resources. These problems result from the problems of social aspects (people's cognition and sense on forest resources, market development, etc.), biological aspects (such as why Korean pine female cones are just settled on top of the tree crown, how many photosynthesis area can support one Korean pine female cone development, what is the proper light environment for seed production of Manchurian lilac, etc.) and technological aspects (such how to compatibly cultivate timber and nut production for Korean pine, Manchurian walnut and Mongolian oak? How to do properly the non-wood product processing for these species? etc.). Developmental strategies for facing these challenges to the multipurpose tree resources in the region were proposed in aspects of forest scientific education, scientific research organization and resource protection, silviculture and development.

multipurpose trees; compatible use; silviculture

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-793 **Multipurpose trees and non-wood forest products, a challenge and opportunity for European silviculture**

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Abstract: The harvest of most Non-wood forest products (NWFP) within Europe has a long tradition and is commonly part of regional culture. It is common knowledge that forests produce much more than wood. Nevertheless, in the past the silvicultural focus within many European countries has shifted towards a single wood production goal, whereby the stand production potential is often not maximised, thus neglecting the production of NWFP. NWFP are often minority products or coincidental goods produced in an informal manner, yet the production NWFP can be positively affected by silvicultural practice; a revision of current silvicultural practices can influence increased yields of NWFP contributing to a multipurpose utilisation of both single trees and forest stands.
The production of NWFP a multipurpose forestry often involves a compromise (i.e. additional workload and/or a decrease in wood production), but may also present additional benefits for the land holder. The modification of one or more treatments within an existing prescription may allow for greater quantities or a more sustainable harvest of NWFP over time, enabling the co-production of non-wood with wood. Some common silvicultural activities are suitable to promote the production of various NWFP such as the choice of provenance and genetics or the choice of management treatment such as thinning and pruning activities. The co-production of contrasting products is possible in many situations, but the land manager must appraise likely outcomes based on temporal and spatial constraints, site conditions (i.e. European location, climate and site productivity), market fluctuation, individual species requirements and management capacities. Likewise, production cost and market prices must be considered in order to estimate the ideal silvicultural system for the optimised production of both, wood and NWFP providing a large potential for the sustainable production of a variety of goods and the support of rural development.

silviculture, NWFP, management, multipurpose trees

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3520 **Collection and consumption of non-wood forest products in Europe**

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Abstract: Although scientific findings point to great potential of Non-Wood Forest Products (NWFP) as an important financial part of the forestry sector, so far there is no systematic overview of their collection and consumption in Europe. This study tries to fill this knowledge gap through a survey which covers twenty-eight European countries. Sampled countries are European part of Russia, Serbia and Turkey, and all EU members except Cyprus, Malta and Luxembourg. Panel-study design of the survey has been set with households as primary unit of analysis. Survey resulted with 17 346 valid responses, where questions covered total of 59 products and different socio-economic parameters. Results show that 89.6% of households have consumed NWFPs in 2015, and that 25.2% of households have picked at least one of them in the same year. NWFPs are predominantly purchased in shops, and most frequently purchased products are fresh and dried nuts and fresh berries. Wild berries and wild mushrooms are the most frequently picked groups of NWFPs. Looking just at the households whose members have picked NWFPs in 2015, majority of them have done so 3-12 times a year, did not attend any courses on the recognition of plants and fungi and did not have any problems during picking. For 0.5% of total households, the picking NWFPs activity represents main source of income, which clearly demonstrates their economic importance. Both collection and consumption of NWFPs increase from West to East Europe.

Non-wood forest products, consumption, collection

Theme 3: Forests and Forest-Based Products for a Greener Future

105 - Sustainable co-production of wood and non-wood forest products

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3278 **The prospection on non-timber forest product at Brazilian Forestry Service - Brazil**

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Abstract: Brazil nest the biggest biodiversity on the Planet representing 20% of total. Although this number impress as a whole the economic non-timber forest product payback is only 30% of total in contrast of timber products.
The objective of this paper is presented a baseline of Brazilian Forestry Service research on non-timber products in which it will contain interviews with the researchers.
The Law nº 11.284, 2006 created the Brazilian Forestry Service (BFS) incorporating inside the Environment Ministry. In 10 years the BFS, produced three projects as following:
1. Project with oleoresins of Copaifera specie used by industry and varnish, cosmetics, pharmaceutical and food industry at North region of Brazil,
2. Project Arboretum is concerned about the cost conservation on building net of seed, herbarium, plantation and recovered net, monitoring and database on forestry diversity,
3. Biodiversity Project focus on the following non-timber products: andiroba, baba çu, castanha do Brazil, pequi, umbu, native rubber, licuri, and others. Those products as the Brazilian Geographic and Statistics Institute represents 50% of total value of non-timber production in Brazil.

brazilian non-timber forest product

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3866 **Optimizing the joint production of pine honey and timber in Mediterranean forests**

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Abstract: Pine honey is an important wild forest product from eastern Mediterranean pine forests, where timber production is also relevant. Pine honey, which can reach high prices in the international markets and represents the main source of income for thousands of people living in rural areas, is produced by bees that feed on the honeydew secretions of Marchalina hellenica, a scale insect that feeds on pine sap. As a result, stands affected by this insect may experience a decrease in forest growth and yield. The aim of our contribution was to optimize the joint production of pine honey and timber by maximizing the soil expectation value of pine stands. Pine stand dynamics and timber production in healthy and infested stands were simulated using forest growth and yield models that account for the effect of M. hellenica on tree growth and mortality. The optimization procedure was based on Hooke and Jeeves algorithm, a direct search method based on nonlinear programming. The results suggest that honey-oriented forest management can be much more profitable than timber production at least in stands growing on medium and poor sites. Thus, pine stands growing on medium and poor sites should be managed using rather long rotations in order to take advantage of the joint production of pine honey and timber, whereas stands growing on good sites may be devoted to timber production if honey yield is low, or to the joint production of honey and timber if honey yield is high enough. Pine honey represents an opportunity to increase the value and economic profitability of pine forests, and further contribute to sustaining livelihoods and the development of rural communities.

NWFP, optimization, management, multifunctionality

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2782 **Discussion on several problems about the cultivation of fruit forests for Korean pine**

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Abstract: Korean pine is the most important high quality timber and economic fruit forest tree species in Northeast China. How to treat the issue about the cultivation of korean pine fruit forest is directly related to the economic development and the safety of wood production in northeast forest region. The prospect and significance, the way of developing fruit forest, site selection, density control, tree form control, mast seeding, grafting propagation, plant diseases and insect pests as well as policy control of the cultivation of korean pine fruit forest were analyzed and discussed based on current forestry situation. It provided reference for the cultivation of korean pine fruit forest in Northeast China.

Korean pine; fruit and timber forest; cultivation

Theme 3: Forests and Forest-Based Products for a Greener Future

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Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3834 **Critical Challenges of Sustainable Production of NTFPs from Tropical Forests: Innovative Approaches to Safeguard Livelihood and Resources**

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Abstract: Globally Non-Timber Forest Products (NTFPs) are getting attention to forestry policy makers and practitioners as NTFPs, play a significant role in the social and economic life of millions of forest dwellers, particularly the tribal, landless, women and other rural poor for cash and non-cash income to local livelihood. Most of the Indian forest areas are facing the problem of low natural regeneration; scientific interventions are required for natural regeneration. There have been very few efforts to reconcile the silvicultural requirements of non-timber species. Sustainable extraction of NTFP is a huge challenge for research due to diversity, phonology and the demand and supply gap. This paper highlights the critical problem of over harvesting of different species and products central Indian states. To overcome such situation, transfer of scientific and indigenous knowledge and interdisciplinary approaches has been adopted by the government, which has resulted to control unsustainable and destructive harvesting. Innovative code of practice through Joint Forest Management Committees has been achieved against declining of key commercially traded species in three habitat types in tropical deciduous forests. There are many policies evolving out of research results, required to implement for more co-production from forests for livelihood support to streamline the rural enterprise.

Un-sustainability, NTFP, Livelihoods, research

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3984 **The potential of Wild Forest Products - a Multi Criteria Analysis across six European case studies**

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Abstract: Tapping the full potential of forest products and services can counteract contemporary global challenges like climate change and sustain livelihoods via poverty reduction and improving food security. In Europe, forests are supposed to play a significant role in fostering the development of a more integrated, bio-based and circular European economy. Wild Forest Products (WFPs) may unlock latent additional potentials of the forest-based sector and provide income to forest owners as well as other stakeholders along the entire value-chain who are willing to invest in related businesses. Considering deficiencies in data availability and data quality the current state of knowledge regarding WFPs in Europe is still fragmented. Thus we apply an expert model approach to unravel both socio-economic and ecological dimensions of forest resources and strive to understand the multiple dimensions of selected WFPs at various spatial and temporal scales. We investigate their potential in different biogeographical zones covering the three major biomes in Europe (i.e. Subtropical, Temperate, Boreal) and discuss economic, social as well as ecological potentials in selected case study regions (i.e. Alentejo, Catalonia, Extremadura, North Karelia, Styria, Transylvania). To mirror diverging interests of individual forest owner types a set of forest owner profiles is applied in the model. Our analysis is clustered in four WFP categories (i.e. Mushrooms & Truffles, Understorey plants, Tree products, Animal origin) and depicts patterns of unique versus abundant resources (e.g. Yello gentian vs Game meat), pinpointing opportunities of innovative (e.g. chaga mushroom, cork) and more traditional products (e.g. berries, resin). Our results indicate that WFPs have the potential to support rural development. It validates the applicability of an expert model that could steer the mindset of forestry stakeholders towards the joint management of wood and non-wood forest resources.

non-wood forest products, co-production

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-639 **Co-Managing Forests for Wood and Non-Wood: Integrating food and medicinal products with timber production for rural people in North America.**

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Abstract: Long before people had the technology to cut timber, they were foraging the forests for food and medicine. That practice continues today, although with little or no professional management. Multiple-use, ecosystem management, biodiversity conservation, have been strategies for managing forests. Objectives of sustainable timber production, wildlife conservation, endangered species protection, and recreation are fully embedded in forest management. The forestry profession is supported by a wealth of science-based knowledge on producing a sustainable supply of fiber. But, there is little science-based knowledge on how to manage the same forests for food and medicine to sustain the lives of people who depend on the same natural resources for mere sustenance. This presentation examines the main issues that affect decisions to integrate these resources into forest management. The economic value of forests from the harvest of non-wood products is discussed and related to the people who benefit from these resources. Examples of the ecological impact of harvesting is presented, as well. The discussion explores what is needed to integrate these resources into forest management to improve people's livelihoods and food and health security. Though based on experience from North America, the discussion is pertinent for all regions.

Co-management, Food, Livelihood, Medicine

Theme 3: Forests and Forest-Based Products for a Greener Future

115 - Recent Strategies of Tree Genomic Researches for High Value Forest Products and Sustainability of

KG I - 1228 (Uni Freiburg)

IUFRO17-1168 **Managing Agroforestry Interventions in Tanzania: A Descriptive Analysis**

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Abstract: Tanzania experiences the high risk of failing to feed herself since the majority of its people relies on rain fed agriculture for their livelihoods. The country ranks low in both the economic and human development indicators. The official statistics show that Tanzania's efforts towards poverty reduction and food insecurity emerges behind in attaining the set targets and even those targets set by the then Millennium Development Goals (MDGs).
Agroforestry seems to be one of the key needed options that the country must opt to arrest these agricultural anomalies. Agroforestry provides the dynamic, ecologically based natural resource management system that integrates trees in agricultural landscapes, diversities and sustain production for increased social, economic and environmental benefits.

The article presents the selected management interventions implemented by the Tanzanian Government to promote agroforestry as one of the initiatives to improve the livelihoods of the the people in Tanzania.

KG I - 1228 (Uni Freiburg)

IUFRO17-3232 **Application of NGS to develop molecular markers for monitoring and selection purposes in the context of climate change**

Kersten, B.* (1); Mader, M. (1); Schroeder, H. (1); Pakull, B. (1); Blanc-Jolivet, C. (1); Liesebach, H. (1); Liesebach, M. (1); Degen, B. (1); Fladung, M. (1)

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Abstract: The rapid development of NGS technologies and bioinformatic tools has paved the way for the assembly of complete genome sequences which may serve as references for the efficient development of molecular markers for different traits or the determination of species and origin of trees (Badenes et al, Front Genet 2016). Recently, we assembled draft nuclear genome scaffolds of Populus tremula x P. alba INRA 717-1B4 (submitted to PlabiPD; http://www.plabipd.de/) and the complete chloroplast and mitochondrial genomes of P. tremula (Kersten et al, PLoS One 2016) as new genome sequence resources for trees. For the development of molecular markers that differentiate species or origin of trees, we successfully applied the cost-effective "genome skimming" strategy (Pakull et al, Conserv Genet Resour 2016; Schroeder et al, PLoS One 2016) and reduced representation strategies such as RADseq (Jardine et al, Conserv Genet Resour, 2016).
NGS strategies are also very useful for the development of diagnostic markers that co-segregate with a trait of interest. NGS sequencing of DNA from phenotypic pools has successfully been applied to develop a diagnostic aspen marker for sex (Pakull et al, Plant Biol 2015), a qualitative trait that is expected to be mono-or digenic. In case of polygenic quantitative traits (e.g., insect tolerance in Quercus robur, drought tolerance in Picea abies) the development of diagnostic markers or even functional markers that are causally linked to the phenotype of interest is more challenging. For this purpose, we intend to use a combination of quantitative RNAseq (stressed versus non-stressed trees) to identify candidate genes (Kersten et al, BMC Genomics 2013) with a subsequent DNAseq of selected candidate genes and their potential regulators in sets of trees representing the contrasting phenotypes. Once developed, such diagnostic markers may be applied for marker assisted selection or for monitoring purposes to cope with the effects of climate change.

NGS, genome skimming, SNPs, InDels, MAS

KG I - 1228 (Uni Freiburg)

IUFRO17-277 **An economic framework for forest genomics research and development in North America**

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(1) Laval University, Institute for Integrated Systems Biology, Quebec, Canada; (2) The University of British Columbia, Department of Forest Resources Management, Vancouver, Canada; (3) Laval University, Department of Wood and Forest Sciences, Quebec, Canada; (4) The University of British Columbia, Department of Wood Science, Vancouver, Canada; (5) Canadian Forest Service, Policy, Economics and Industry Branch, Vancouver, Canada; (6) The University of British Columbia, Department of Forest and Conservation Sciences, Vancouver, Canada

Abstract: Canada and the US have pioneered large-scale genomics projects in forestry. An estimated $123M have been invested in forest genomics research between the years 2001-2015 in Canada alone. However, this recent research field is poorly understood by the public and forest managers, though it is rapidly expanding, and many new potential uses of the genetic information gained are being developed such as those related to generalized technologies for use in industrial plantations and/or natural forests as well as within process optimization, product development and international trade facilitation. While, some of these uses are primarily economic in nature, others are additionally advantageous to ecological or social goals, such as pest resistant trees that can withstand the effects of insects or diseases. Here, we identified research priorities and potential economic implications based on a total of 36 forest genomics projects by: (a) developing a robust typology of forest sector genomics research relevant to Canadian application; (b) categorizing each initiative for its application potential (commercial, non-commercial); and, (c) demonstrating with silvicultural gain, insect resistance, and wood composition themes the application of modeling and economic analysis. Furthermore, we applied our findings to conduct an economic assessment of an independent set of seven forest genomics research projects in Canada, including value judgements on the potential of commercialization and research application. The outcome of our work allowed us to (1) categorize the projects by type including the description of the economic frameworks, (2) undertake an economic assessment of each of these projects, using qualitative and quantitative (if available) information and (3) provide advice and a value judgement on the necessary micro-level economic conditions for application and commercial success.

impact assessment;tech transfer;genomics;themes

Theme 3: Forests and Forest-Based Products for a Greener Future

115 - Recent Strategies of Tree Genomic Researches for High Value Forest Products and Sustainability of

KG I - 1228 (Uni Freiburg)

IUFRO17-102 **Functional Genomics of High-Value Bioproducts in Tropical Sandalwood**

Bohlmann, J.* (1)

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Abstract: Functional Genomics of High-Value Bioproducts in Tropical Sandalwood

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Tropical sandalwood (Santalum album) produces one of the world's most highly prized fragrances. The fragrant sandalwood oil is extracted from the heartwood of mature trees. Historical overexploitation has threatened many natural populations of this slow growing, hemiparasitic tree. Alternative production systems for sandalwood oil include plantation forestry and engineered microbial production systems. The development and optimization of both of these system benefits from genomic advances of sandalwood oil production. Sandalwood oil contains four major and fragrance-defining compounds, the sesquiterpene alcohols (Z)-alpha-santalol, (Z)-beta-santalol, (Z)-epi-beta-santalol and (Z)-alpha-exo-bergamotol. The first committed step in their biosynthesis is catalyzed by a multiproduct terpene synthase, santalene/bergamotene synthase, which produces alpha-santalene, beta-santalene, epi-beta-santalene and alpha-exo-bergamotene. Formation of the corresponding sesquiterpene alcohols involves stereo-selective cytochrome P450 (P450) enzymes. Metabolite profiling and transcriptome analysis of plantation trees revealed a spatially unique heartwood transcriptome signature for sandalwood fragrance biosynthesis. In this project, we discovered the entire set of biosynthetic genes and enzymes of key components of sandalwood fragrance, which enabled alternative production systems for sandalwood oil fragrances.

Celedon et al. (2016) The Plant Journal, doi: 10.1111/tpj.13162

Sandalwood, bioproduct, functional genomics

KG I - 1228 (Uni Freiburg)

IUFRO17-3060 **Molecular mechanisms regulating nut weight in Castanea crenata**

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Abstract: Chestnut (Castanea crenata) is an important short-term income tree crop in Republic of Korea. Traditional selections on chestnut quality resulted in a huge diversity of both weight and sugar content, which further provide excellent resources to exploit the molecular bases of those diversity. To systematically understand its molecular mechanisms during fruit development, we first performed both metabolomic and transcriptomic analyses with two small (JW) and large (DH) nut-bearing varieties. A total of 42 water-soluble metabolites were differentially accumulated in nut tissues between JW and DH. Among those metabolites, the contents of monosaccharides were significantly different between two varieties during the entire periods of fruit development. Interestingly, the content of sucrose in both leaf and fruit tissues at the early stage of fruit development showed significant correlations with nut weights ($r>0.7$, $p<0.05$). We also generated 37,649 unigenes matching 97.9% of the C. mollissima genome by single molecule real-time sequencing. Further transcriptome analysis using Illumina high-throughput paired-end sequencing provided a number of differentially expressed genes involved in seed development and fruit size, respectively.

Chestnut, metabolome, transcriptome

Theme 3: Forests and Forest-Based Products for a Greener Future

Research Advances for the Meliaceae

KG I - Aula (Uni Freiburg)

IUFRO17-3263 **Patterns of pollen- and seed-mediated gene flow in three rain forest timber species from the Entandrophagma genus (Melicaeae)**

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Abstract: Background. Pollen and seed dispersal are key processes affecting the demographic and evolutionary dynamics of plant species. We characterized using direct (based on parentage analyses) and indirect (based on fine-scale spatial genetic structure analyses) genetic approaches the mating system, the extent of pollen and seed dispersal of three African rain forest timber species from the Entandrophragma genus. These species are pollinated by insects (bees) and seeds are dispersed by wind.

Material and methods. For the three species (E. candollei, E. cylindricum and E. utile), we sampled and genotyped (using nuclear microsatellite markers), adult trees, seeds and saplings in a 400-ha and a 900-ha study plot in a natural forest from East Cameroon.

Results. Preliminary analyses support high outcrossing rates in all three species. Both seed- and pollen-mediated gene flow appear to be very efficient.

Discussion & Conclusion. Patterns of gene flow will be compared and discussed among these three congeneric species accounting for species characteristics that influence gene flow patterns such as densities of adult individuals (generally in South Cameroon E. cylindricum > E. candollei > E. utile) and seed weight (E. utile > E. cylindricum > E. candollei). These new data on the reproduction biology of these three high-value timber species will help to orientate sustainable logging practices.

Meliaceae; logging; gene flow; management

KG I - Aula (Uni Freiburg)

IUFRO17-1110 **Selection of seed sources - a crucial factor for effective conservation of genetic resources of Melia Dubia**

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Abstract: The largest, cheapest and fastest gains in most forest tree improvement programs can be made by assuring the proper use of species and best seed source within species. Thus, the choice of proper seed source is a major factor to be considered while embarking on the establishment and productivity of plantations of forest trees. Melia dubia Cav., a fast growing native tree species has been introduced into plantation forestry in India. Due to its straight and fast growth, short rotation period and pulping characters it is preferred by many wood based industries. Reports state that large-scale planting is hampered by poor seed (< 10 %) germination, despite producing abundant quantities of fruits. A study was conducted to understand reasons for poor germination in this species. Fruits collected from single trees, plantations and natural populations were observed for their physical characteristics. Seed filling was observed in depulped fruits and viability of seeds tested. Fruits collected from single trees were single seeded or unfilled while fruits collected from natural populations had all locules filled. Fruits from plantations raised from a single seed source showed poor filling, while plantations raised from different seed sources showed better filling. Germination and seedling fitness showed a similar trend with seeds from natural populations having as high as 75 percent germination as against the reported ten percent in literature. Seedling survival and vigour were also greater for seeds from plantations. This clearly indicates a strong tendency for outcrossing in the species, though it is also clear that there is a considerable potential for selfing. Hence care should be taken to collect fruits from natural stands / plantations as selfing and limited mobility of pollen in single trees would result in reducing variation within the species resulting in a reduction in quality and quantity of the planting stock leading to plantations with low productivity.

KG I - Aula (Uni Freiburg)

IUFRO17-2604 **Survival and growth of mahogany (Swietenia macrophylla) 20 years after planting in Mexico's community forests: effects of silvicultural treatments**

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Abstract: Twenty-four 5000 m2 regeneration clearings were created, 8 each by slashing undergrowth and complete felling; slashing, felling and subsequent burning; and machine clearing, which uprooted preexisting vegetation. Twenty mahogany seedlings were planted on plots in the centre of each clearing. On half the clearings, seedlings were cleaned twice during the first 2 years. Twenty years later, survival ranged from 10% on burned clearings where seedlings had not been cleaned to 34% where they had. All mahoganies had died on six experimental plots where they had not been cleaned, reducing the replicates of each clearing and cleaning combination from four plots to two. As a result, GLM tests on arcsine-transformed survival and log-transformed diameter revealed statistically significant effects of cleaning ($p=0.007$ and $p=0.061$, respectively), but not of clearing treatments. The fastest-growing cleaned mahoganies averaged 20.5 cm dbh on felled clearings, 17.3 cm dbh on burned clearings and 8.6 cm dbh on machine-made clearings. The impact of cleaning and clearing treatments on survival and growth has changed with each five year analysis, revealing the importance of long-term remeasurements. To retain sufficient numbers of replicates to determine the significance of key factors over decades requires planting 100 or more seedlings per experimental plot.

Silviculture, tropical forest, burning, cleaning

Theme 3: Forests and Forest-Based Products for a Greener Future

Research Advances for the Meliaceae

KG I - Aula (Uni Freiburg)

IUFRO17-185 **Genetic trials of mahogany and Spanish cedar in Quintana Roo, Mexico after almost 20 years**

Ward, S.* (1)

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Abstract: Mahogany (Swietenia macrophylla) and Spanish cedar (Cedrela odorata), are in high demand globally and in Mexico for their valuable wood, but few trials had been established for genetic conservation or tree improvement. In 1996-1999, genetic trials of mahogany and Spanish cedar were established in Quintana Roo at several ejidos, on the grounds of the Bacalar Experimental Station, and on the lands of a private land holder. The germplasm came from seed collected from each species around the Yucatan Peninsula, as part of larger collections that were made from Mexico to Panama. This project was a collaborative effort among the Instituto Nacional de Investigaci ón Forestales y Agropecuarias (INIFAP), Centro Agronómico Tropical de Investigación y Ensenañza (CATIE), the World Agroforestry Centre (then ICRAF), and the US Forest Service. Of the original three mahogany trials, the one on private land (Rancho Grande) and those at INIFAP remain. The Spanish cedar trials at Noh Bec and at INIFAP also remain. In 2013, the Spanish cedar trial at Noh Bec, and in 2014, the mahogany at Rancho Grande, were remeasured to determine the best sources for growth and survival. For the mahogany trial, after 18 years, 51% or 491 out of 960 trees planted were alive, the mean diameter at breast height (DBH) was 13.4 cm (± SD 6.8 cm), and the mean clean trunk or bole was 4.5 m (± SD 2.7 m). DBH had a heritability of 0.37. For Spanish cedar after 16 years, 44% or 482 out of 1085 trees planted were alive, the mean DBH was 5.7 cm (± SD 2.6 cm, with a maximum of 14.8 cm), and the mean clear trunk or bole was 3.15 m, (± SD 1.2 m). For the Spanish cedar, no significant differences in growth at 16 years were found among families. The mahogany trial will be converted to an improved seed orchard, eliminating the poorest sources, while maintaining genetic variation. The Spanish cedar trial will also be converted to a seed stand. These seed orchards will provide seed for local producers.

Swietenia macrophylla, Cedrela odorata, genetic

Theme 3: Forests and Forest-Based Products for a Greener Future

94 - Ecologically-based silviculture

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3831 **Changing stand structures in plantations: a very large challenge**

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Abstract: For decades, logging has led to significant changes in composition and structure of the forests of Eastern Canada, transforming the landscape into a mosaic of regular/even-aged stands. Developing operationally feasible silvicultural treatments to reintroduce structural complexity have recently been proposed in the province of Quebec, in order to meet the close-to-nature requirements of the Sustainable Forestry Act. Such treatments should not however hinder stand productivity. In 2008, a commercial thinning trial, consisting in the removal of competitors around elite trees (ET), was initiated as the first step of a structural conversion treatment to transform regular/even-aged stands to irregular/uneven-aged stands through the use of commercial thinnings. Four different thinning treatments (from below, 50 trees/ha or 100 trees/ha ET release, control) were tested in white spruce (*Picea glauca*) plantations and precommercially thinned balsam fir (*Abies balsamea*) dominated natural regeneration stands. In 2014, we measured these experimental plots for growth increment and stand structural diversity. At the stand level, no differences were observed amongst the treatments for average cumulative basal area increment since thinning. At the tree level, trees thinned by ET release showed a significantly higher DBH increment than those in the control plots. The released ET also had higher DBH increments than their closest neighbors. The released ET had less competition than the potential ET in both the control and thinned from below plots. The spatial complexity of the plots did not however significantly increase after ET release, even if ET thinnings was as systematic as thinning from below. This last result indicates that the number of ET released is not high enough to change stand structure with only one thinning, as the pre-harvest stand structure is still very important in the thinned stands. Further interventions are thus needed to reach the close-to-nature objectives.

close-to-nature management, commercial thinnings

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-4107 **Evaluating structural, compositional and economic tradeoffs of ecologically-based silvicultural approaches in mixed-species forests of the Mississippi River floodplain**

Frey, B.* (1); Nepal, S. (1); Henderson, J. (1); Roberts, S. (1); Grebner, D. (1)

(1) Mississippi State University, Mississippi State, United States

Abstract: Ecologically-based silvicultural approaches that prioritize non-timber values are increasingly challenging traditional even-aged timber-focused paradigms of forest management. In the complex, mixed hardwood forests of the Mississippi River floodplain, continuous cover type approaches, particularly aimed at wildlife species of high conservation concern, are being widely promoted with uncertain impacts on long-term stand structure, composition, and economic viability. The objectives of this study were to model and compare stand development and economic tradeoffs associated with alternative management approaches. We used the US Forest Service (USFS) Forest Vegetation Simulator to simulate stand growth under alternative even- and uneven-aged management scenarios. Inventory data from the USFS Forest Inventory and Analysis program was used to provide initial stand conditions for a range of forest types, site qualities, and stocking conditions. Analyses suggest that while uneven-aged management approaches can favor greater structural complexity, potential compositional shifts to shade-tolerant species can have negative economic consequences. However, these tradeoffs are highly dependent upon initial stand conditions. In mixed species forest types, ecological-based silvicultural approaches will need to carefully consider structural and compositional tradeoffs, and adjust their implementation to balance social, ecological, and economic benefits for landowners and the public.

Uneven-aged, silviculture, wildlife habitat

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3897 **Understanding growth: scaling production ecology from trees to stands**

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Abstract: The patterns of growth of trees and stands may be addressed statistically (quantification of patterns) and functionally (process-informed explanations). The functional approach to explaining growth in terms of resource supply, acquisition, efficiency of use, and partitioning at the scale of stands has been developing for over 4 decades. This production ecology approach to examining growth of individual trees within stands expanded substantially in the past decade. We review recent findings from forests around the world on patterns of production ecology among trees within stands, and how these tree-to-tree interactions scale up to explain stand-level growth. Single-species stands typically show that dominant trees not only acquire a greater proportional share of site resources than smaller trees, but they also produce more stemwood per unit of resource used. Some notable exceptions to this generalization do occur. Insights from mixed-species stands may be more variable, and the degree of resource use efficiency by dominant trees may be an important factor explaining the influence of species diversity in stand-level growth.

Theme 3: Forests and Forest-Based Products for a Greener Future

94 - Ecologically-based silviculture

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-439 **The temporal dynamics of net primary production of loblolly pine plantations in the southern United States**

Zhao, D.* (1); Kane, M. (1)

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Abstract: Pine plantations in the southern US are among the most intensively managed forests in the world and their productivity has tripled over natural pine forests through application of intensive plantation establishment and management practices. To strengthen financial returns and sustainably manage pine plantations for a mixture of traditional merchantable forest products and biomass for energy, we need to modify and optimize loblolly pine (Pinus taeda L.) plantation management regimes. The information on long-term dynamics of net primary production (NPP) of loblolly pine plantations is critical to evaluate alternative culture regimes, but limited. Based on the re-measurement data from the plots of loblolly pine culture and density studies with a combination of two levels of cultural intensity (operational vs. intensive) and six levels of planting density (740 - 4440 trees/ha) across the southern US, we first estimate the NPP for each plot from ages 4 to 18 years and then investigate how cultural intensity, planting density, and site quality influence the change of NPP over time. The relationships between the NPP and stand structures such as tree size inequality, foliage density and environmental variables will also be reported.

pine plantation, NPP, intensive management

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-575 **Climatic and genetic control on carbon fluxes and partitioning in Eucalyptus plantations**

Campoe, O.* (1); Alvares, C. (2); Carneiro, R. (3); Stape, J. L. (2); Binkley, D. (4); Ryan, M. (4)

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Abstract: Intensively managed Eucalyptus plantations cover 5.6 million hectares in Brazil, from 0o to 33o South, influenced by a wide range of climatic conditions. We selected 4 sites, among a 36-site research platform, covering a range of mean annual temperature (18 to 28 ^{o}C), annual precipitation (1,000 to 1,800 mm) and annual water deficit (0 to 600 mm). Additionally, we selected 5 contrasting Eucalyptus clones repeated on each site. The objective was to evaluate climatic and genetic controls on carbon fluxes and partitioning, and their interaction, on intensively managed Eucalyptus plantations. Over two consecutive years (~3 to 5 years) we measured carbon fluxes to calculate aboveground net primary production (ANPP), total belowground carbon fluxes (TBCF), and partitioning (ANPP:TBCF). Differences in ANPP among climates and genotypes ranged from 315 to 5,500 g C m^{-2} $year^{-1}$ (similar range for TBCF). Severe climates among sites resulted to more carbon partitioning to belowground processes, similarly to genotypes developed for harsh climates (ANPP:TCBF from 0.20 to 1.54) . The most productive genotypes showed higher partitioning to ANPP and to wood production. Interactions among climate and genotypes were significant. Evaluate how climatic variation affects carbon fluxes and partitioning is key to understand potential effects of climate change on genotype selection for wood production.

Eucalyptus, climate, carbon flux, productivity

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2477 **Responses of photosynthesis and growth of sprouting seedlings for three different shade-tolerate tree species to gaps of temperate secondary forests: the roles of gap size and within-gap position**

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Abstract: Secondary forests, accounting for more than 50% of the total area of national forests, have become major forest resources in China. Forest gaps, recognized as a dominant form of small-scale disturbance in secondary forests, play an important role in forest regeneration and succession. The principal goal of current forestry development is to facilitate the regeneration of dominant tree species to recover secondary forests, and promoting the natural regeneration in forest gaps is a key measure to achieve the goal. Furthermore, the within-gap position and gap size are two key characteristics of gaps to affect tree regeneration by changing micro-environment. Sprouting regeneration from stumps happens after the gap formation by logging. Twelve artificial gaps were created in March 2015, and sprouting seedlings at five within-gap positions and two gap sizes of three different shade-tolerate tree species (Quercus mongolica, Acer mono, and Tilia mandshurica) were selected in this study. The photosynthesis and growth of these sprouting seedlings were monitored in 2016. The results showed that the photosynthetic ability for different shade-tolerate tree species changed in consistent with the light intensity at corresponding within-gap position. The minimum values of PNmax for sprouting seedlings of shade intolerant tree species (Q. mongolica) occurred at the lower irradiance zone of gaps (southern part of gaps). Gap size only had significant effects on the Chl and Car contents in leaves and relative growth rate of basal diameter of T. mandshurica sprouting seedlings. Effects of gaps on sprouting seedlings growth was not completely consistent with the photosynthetic responses. The sprouting seedlings could get enough nutrition to maintain growth, thus the effects of gap environments on the growth of sprouting seedlings is limited at the early stage of gap formation. This study could provide some scientific reference for the restoration of broadleaved secondary forests.

Growth rate, Restoration of secondary forests

Theme 3: Forests and Forest-Based Products for a Greener Future

94 - Ecologically-based silviculture

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-4111 **Growth dominance across a productivity gradient: light competition and light use efficiency**

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Abstract: Growth dominance expresses the relative contribution of individual trees to stand growth in relation to their relative contribution to stand biomass. But does growth dominance relate to tree resource acquisition and resource use efficiency? We re-analyzed growth dominance patterns from 12 plots across a productivity gradient in a six years old Eucalyptus stand in Southeast Brazil. We tested for positive Pearson correlations (r) between growth dominance, asymmetric competition (we used a light dominance index) and differences in light use efficiency among trees. Growth dominance averaged 0.155 across plots (CV: 27%) was positively correlated with productivity (p-value: 0.048; r: 0.50). Largest trees (trees in the upper 20% of the biomass distribution) represented 27% of stand growth, captured 25% of the light and were 1.5 times more efficient than smallest trees. Light dominance index averaged 0.010 (CV: 36%) and was not correlated with growth dominance (p-value: 0.631; r: -0.11). In general light use efficiency increase linearly with tree size and the slope tended to be positively correlated with growth dominance (p-value: 0.064; r: 0.46). Light dominance index and light use efficiency tended to be negatively correlated (p-value: 0.057, r: -0.48). The variation in the trends was large, and more investigation into factors influencing the relationships between resource use, resource use efficiency and growth dominance will show if these initial patterns are robust.

Production ecology, asymmetric competition

Theme 3: Forests and Forest-Based Products for a Greener Future

152 - Resources for the Future Task Force: Institutions for Forest Transformation

KG I - 1199 (Uni Freiburg)

IUFRO17-1703 **Characteristics of co-benefit program development of Forest Carbon Projects in the Voluntary Carbon Market**

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Abstract: The global society agreed to acknowledge various forms of carbon crediting mechanisms and noted the significance of sustainable development and environmental integrity through the Paris Agreement at the 21st session of the Conference of the Parties to the UNFCCC. Under the new climate regime, a forest carbon project, which may include various co-benefits, is expected to gain more attentions in the carbon market. This study analyses characteristics of co-benefit from forest carbon projects developed in the voluntary carbon market. In order to analyse the development pattern of co-benefit programs, 72 forest carbon projects that have issued and retired carbon credits in the market were analysed with frequency analysis and Multi-Dimensional Scaling analysis based on project type, project size and project site attribution (level of economic development). The projects were classified into three clusters, which are Improved Forest Management (IFM) projects in developed countries, small-medium scale forest carbon projects in developing countries, and large scale Reducing Emissions from Deforestation and Forest Degradation (REDD) projects in developing countries. Different development patterns of socio-economic and environmental co-benefit programs were identified in the clusters. It can be inferred that co-benefit programs of forest carbon projects were developed depending on the type, size, and site attributions of the projects. To promote co-benefits of forest carbon projects, the introduction of an objective co-benefit assessment and certification system should be reviewed.

forest carbon project, co-benefit, carbon market

KG I - 1199 (Uni Freiburg)

IUFRO17-138 **A Framework for Governance of Institutional Investment in the Forestry Sector**

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Abstract: Institutional investment in the forestry sector has grown steadily over the past 30 years and now is estimated to have reached $US100 billion. While over 70% has been in the United States, forestry investment is now expanding to many countries around the world. Institutional investment in forestry is driven by portfolio design considerations, and particularly the search for low volatility assets with good cash yield, low correlation with other asset classes, and potential for matching long-term liabilities like pension payments. Institutional investors have increasing emphasis on sustainable and responsible investment practices, and choose investment managers who are aligned with their investment policies and objectives. A growing aspiration is the concept of shared value. In the forestry sector this implies that investment management and governance systems will seek to generate positive community benefits and stable, risk adjusted returns to investors as equal and mutually reinforcing goals. This paper discusses the current thinking around multi-factor performance monitoring and management in forestry investment and proposes a framework of criteria to assess landscape scale outcomes from forestry investment activities.

Forest Investment, Shared Value, Governance

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IUFRO17-1093 **Resources for the Future: An Overview**

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Abstract: This oral presentation provides a review of findings from the IUFRO Resources for the Future Task Force, focused on Transformation in Forest Use. The Task Force brings together experts and leaders on forest policy and governance from around the globe, who have shared insights on the performance of institutions and policy to support a transition to more sustainable forest resource use.

These lessons and insights will be synthesised and shared in this oral presentation. General conclusions for forest institutions will be provided by Drs. Innes and Nikolakis.

forest governance; public policy; adaptation

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IUFRO17-1005 **Spatial distribution of households vulnerable to deforestation in non-timber forest product collections in Kampong Thom Province, Cambodia**

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Abstract: The livelihood of rural residents is often dependent on Cambodian forests as it provides non-timber forest products (NTFPs). Such forests, however, are rapidly diminishing because of developments in the areas of agribusiness, subsistence agriculture, and timber extraction. Some of the people affected by these developments around their villages either relocate their collection sites or convert distant forests to other land uses to compensate for their income loss. These coping strategies can create conflicts in NTFP collections and affect the livelihoods of the residents of other forests. This creates a vicious circle of further conflicts and forest losses. To address this problem, immediate policy interventions and measures are required to relieve the affected people and to prevent further issues due to deforestation in terms of NTFP collections. With this background and a focus on the affected Kampong Thom province, our study, combined with household surveys and remote sensing analysis, estimates the numbers and mapping of the spatial distribution of households vulnerable to impacts of deforestation. We draw implications for cost-effective forest management as well as policy, thereby addressing the vicious circle of deforestation in the province by taking the number and geographical distribution of the vulnerable households into account.

deforestation, non-timber forest products

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IUFRO17-4009 **Mixing policies and institutions for conservation impact: examples from Latin America**

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Abstract: Externalities are core to most conservation problems: the wide range of beneficiaries of forest products and environmental services do not have enough of a say in key resource-use decisions made by forest stewards or owners. Command-and-control measures (forest laws, protected areas, etc.) have been the traditional way to address those, while more recently a paradigm of conditional conservation incentives (PES, certification, REDD+) has gained more traction. However, looking at these incentive tools in practice, they are almost never implemented in their purely conceptualized form. In part, this is due to the complex interaction between community, market, and state (hierarchical) institutions at play. National PES programs are politically often born only in tandem with weighty non-environmental, human welfare objectives. They can predominantly only be implemented with strong complementary "sticks", e.g. laws or regulatory threats superimposed on PES programmes. Subnational REDD projects are typically being dominated by traditional community-based integrated conservation and development programs (ICDP). And incentive conditionality is de facto often poorly, if at all applied. Using examples from Latin America, this presentation explores political economy reasons why we seldom see forest conservation incentives implemented as standalone policies, and develops some hypotheses under what circumstances these vis-à-vis theory 'contaminated' incentive policy mixes can still deliver desirable outcomes for forests and people.

incentives, PES, regulation, REDD, policy mix

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IUFRO17-4054 **Institutions for transformation towards sustainable forest management: a comparison of NW Russia and Sweden**

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Abstract: The Baltic Sea Region in northern Europe hosts strikingly different institutional set-ups and forest landscape histories for forest transformation towards sustainable forest management. Focusing on Sweden and Russia the aim of this paper is to contribute to the understanding of barriers and bridges in social and ecological systems towards balancing forestry intensification, rural development and biodiversity conservation in different contexts. This requires that past development trajectories are understood. Using an environmental history approach for representative forest regions we (1) recreated the forest use history since 1800, (2) identified the main actors that produced this history, and (3) analysed what ideologies influenced decision making. Results demonstrate the incompatibility of maximum sustained yield forestry with other sustainability objectives. In Russia, barriers to intensification include Soviet legacies of large-scale harvesting, which resulted in a very uneven age distribution, limited and poorly conducted silviculture, as well as insufficient transport infrastructure. Additional barriers are a conservative mind-set at the policy level, unpredictable conditions for forest use rights and ownership, and limited value-added production at local level. In Sweden, barriers to biodiversity conservation and rural development include a long history of forestry intensification, strong domination of forest industry interests, and conservative forestry education. This requires learning about societal development trajectories linked to ownership, governance and tenure systems as well as forest landscape history. Developing predictable rules and norms, forest zoning at local to regional scales, and application of place-based multi-level collaborative learning concepts like Model Forest provide opportunity for bridging the observed barriers.

Governance vs.government, comparative politics

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13 - 125 years of cultivating Norway spruce - what have we learnt and lessons for the future

K 8 (Konzerthaus Freiburg)

IUFRO17-2513 **History of thinning experiments in Sweden with Norway spruce**

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Abstract: From start of the Swedish Forest Research Institute 1902 growth capacity and thinning of Norway spruce were important tasks and many experiments were established. From around 1930 until 1960s resources were mainly used for temporary plots where reconstruction of growth was done with increment cores. During this period e.g. spacing experiments but few thinning experiments were established. During the 1960-s the forest sector in Sweden developed fast and it was obvious that existing field experiments could not provide information needed. From end of 1960:s a new serie of thinning experiments were established in Sweden. The treatments included more traditional programs as well as earlier not tested programs as thinning from above and one very heavy (70%) thinning. The first generation of thinning experiments, some now more than 100 years old, still give valuable information for management of Norway spruce, about growth and yield, rotation, production in first and second generation. The second generation of thinning experiments give not only possibilities to study more traditional characteristics as diameter and volume yield but also the effect on wood properties as basic density and amount of juvenile wood. The different field-experiments have been and still are, a most valuable source of information when forming management principles for Norway spruce in Sweden

Norway spruce, thinning, field-experiments

K 8 (Konzerthaus Freiburg)

IUFRO17-2210 **Long-term study of advanced establishment of beech (Fagus sylvatica L.) below Norway spruce shelter (Picea abies [L.] Karst.)**

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Abstract: In 1996 a long-term trial was initiated by the German branch of IUFRO "Deutscher Verband Forstlicher Forschungsanstalten" (DVFFA, Silviculture Division) to move away from monocultures by artificially establishing European beech (Fagus sylvatica L.) underneath the canopy of pure Norway spruce stands (Picea abies (L.) Karst.). As sowing is considered to be an economically and ecologically interesting alternative to planting, permanent testing areas were established in three federal states (Bavaria, North-Rhine Westphalia and Saxony). The present study is the first and simultaneous evaluation of all sites. Results give an interesting view on the growing process for the first 9 years.

The data set consists of time series (longitudinal data) of four locations (Arnsberg, Freising, Landshut and Tharandt). After data preparation, non-linear mixed models (NLMM) were used as a flexible tool to analyze the grouped data. We assume that the growing process of the beeches is influenced by random effects, e.g. location and by fixed effects, e.g. establishment method, liming, and ground cover. The model fit was improved stepwise, taking heteroscedasticity and time autocorrelation into account.

Results show significant differences in height development between sown and planted beeches. In this context we discuss the influence of random and fixed effects on the growing process of beech trees.

conversion; seeding; advanced planting; beech

K 8 (Konzerthaus Freiburg)

IUFRO17-1316 **High-quality Norway spruce for (clime-) dynamic breeding zones**

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Abstract: Today Norway spruce is the economically most important tree species in German forests: regional, fast-growing and not universally replaceable by another tree species. Like no other tree species spruce splits the opinions. On the one hand economic backbone, on the other hand considered as unsustainable, unnatural and vulnerable not only to climate change. But to ensure a sustainable and high-quality timber supply for future generations adaptable stands are needed, especially spruce.

Vital and productive trees with high adaptative potential are required to support a local and sustainable production of high-quality timber (economy) and vital spruce stands on suitable sites (ecology), even under changing climatic conditions.
Identifying so called plus trees and using them as basic material to establish new seed orchards is one of the main objectives of the German-wide project "FitForClim".

To this end, plus trees were selected primarily from forest genetic field trials, based on an inter-institutional analysis of long-term data from those trials. The same data was also used in combination with climate data sets in order to delineate breeding zones with (clime-) dynamic ranges to enable flexibility to environmental changes.

seed production, climate change, Norway spruce

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IUFRO17-1342 **Green, Circular, Bio economy: a comparative analysis of sustainability narratives**

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(1) Department of Forest Sciences, University of Helsinki, Helsinki, Finland; (2) Helmholtz-Centre for Environmental Research , Leipzig, Germany; (3) Institute for European Environmental Policy (IEEP), London, United Kingdom; (4) University of Vaasa, Vaasa, Finland; (5) Finnish Environment Institute, Helsinki, Finland; (6) Indufor Oy, Helsi, Finland

Abstract: Circular Economy (CE), Green Economy (GE) and Bioeconomy (BE) are currently mainstreamed in academia and policy making as key sustainability narratives. Despite their evidently different assumptions, visions, aims and operationalization strategies, a comparative study of such narratives is missing. The aim of this article is thus to systematically analyse the diversity within and between such narratives. The results are drawn from a bibliometric review of scientific literature published within the three decades, coupled with a conceptual analysis. We find that, for what concerns environmental sustainability, GE acts as an 'umbrella' narrative, including several concepts from CE and BE narratives (e.g. eco-efficiency; renewables), as well as additional concepts, e.g. nature-based solutions. In particular, CE and BE are resource-focused, whereas in principle GE acknowledges the underpinning role of all ecological processes. Regarding the social dimension, GE is more inclusive of some aspects at local level (e.g. eco-tourism, education). A part of BE literature, however, discusses local processes in terms of biosecurity and rural policies. When considering weak/strong sustainability visions, all narratives remain limited in questioning the economic growth paradigm. The findings are discussed in light of the narratives' synergies and limits, with the purpose to inform research and policy implementation.

Bioeconomy; Green economy; Circular economy;

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IUFRO17-2817 **Business Practices for a Circular Bioeconomy in Germany - An explorative analysis**

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Abstract: Scholarly and political debates focusing on the bioeconomy recently experienced a rise of the concept of a 'circular' bioeconomy, particularly in Europe. In these debates, new business models and practices are repeatedly highlighted as being crucial for the transition towards a circular bioeconomy.
Yet, to what extent has the debate reached businesses and how does it contribute to innovation? To answer this question, an exploratory study of business stakeholders in Germany is presented. Based on extensive participant observation of business conferences, a group discussion, as well as document analysis, this analysis presents an explorative overview of innovative business practices and new business models aiming at a circular bioeconomy in Germany.
The analysis maps novel business practices, explores why these have become understood as being circular, and scrutinizes which understandings of 'circularity' and which types of practices dominate.
The analysis reveals that current practices focus on technology-driven understandings of circularity, e.g. materials recycling, whereas social innovations and new business models, such as leasing or sharing, remain largely unexplored. Contextualizing their understandings and practices with core paradigms of a circular economy as brought forward by key scholars, the results show that current business practices in Germany mostly remain in old paradigms of a linear economy. Hence, it is questionable whether they will contribute to a transition towards a circular bioeconomy.

business, innovation, transformation, economic

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IUFRO17-3650 **A Ten-Year Review of Sustainable Development: A Case Study of Stora Enso and Asian Pulp & Paper**

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(1) Nanjing Forestry University, Nanjing, China

Abstract: The forest sector plays a critical role in global sustainability development for its use of renewable resources and potential for sustainability practice. However, its dependence and impacts on natural resources have placed the forest sector under intense public scrutiny. Sustainability endeavors are thus prerequisites for the companies to comply with regulations and maintain legitimacy. Drawing upon managerial and sustainability theories, this paper studies the overall patterns of Stora Enso and Asian Pulp & Paper philosophical and practical views on sustainable development, and the impact of these views on their values, visions, business environment, strategic management, environmental policies and moves towards environmental sustainability. The data is based on the sustainability reports of 2006-2015 published by the two case companies. The software ATLAS.ti 7.0 is applied in the content analysis. Our results indicate that both companies have moved towards sustainable development. Their business environment has firmly rooted in eco-centrism but there are variations in the companies' management to keep pace with it. Stora Enso seems to have run ahead of Asian Pulp & Paper in terms of competitive environmental moves, strategic aggressiveness. In the long run, both companies need to meet the sophisticated demands of both their business environment and ecological environment.

sustainability reporting, content analysis

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IUFRO17-3566 **Managerial Perceptions of Carbon Emission Trading in China: An Exploratory Study from the Domestic Forest Industry**

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(1) Nanjing Forestry University, Nanjing, China; (2) Oregon State University, USA, Corvallis, United States; (3) Kyoto University, Japan, Kyoto, Japan

Abstract: As China begins the shift towards a national emission-trading-system (ETS) to be implemented in 2017, there will be many opportunities for it to benefit from both best practices in carbon markets and by ensuring its ETS is ready to link with others factors. This new system creates considerable uncertainty for companies, particularly regarding the nature of the carrot-and-stick approach and the role of trading in realizing emission trading. Based on semi-structured interviews with twenty-five Chinese forest company managers, this paper investigates what drives companies to show interest in emission trading and carbon offset projects to deal with climate change. Our preliminary results indicate that although the development of carbon trading in China is still in its infancy, there is likely a rapid evolution as the country experiments with different options. Managers show concern about how to operate a market-based instrument given the current shortcomings of the Chinese market system. Implications of the findings on emission trading and climate mitigation are also discussed regarding how companies can be better positioned to facilitate compliance and innovation.

climate policy, national ETS, carbon offset

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IUFRO17-2878 **Harnessing the Potential of Productive Forests and Timber Value Chains for Climate Change Mitigation and Green Growth: Private Sector Opportunities**

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(1) UNIQUE, forestry and land use, Freiburg, Germany

Abstract: The presentation is based on a study conducted for World Bank to evaluate the opportunities on how to harness the potential for climate mitigation and green growth in the forestry sec-tor. The study was conducted for six countries - Colombia, Ethiopia, Mexico, Mozambique, Peru, and Viet Nam - focusing on mitigation benefits related to carbon storage in planted forests, harvested wood products (HWP), and from the substitution of non-wood materials. Additionally, the study quantified the climate change adaptation benefits of investments in the HWP value chain, such as creating economic opportunities and increasing resilience.
HWP production is labor intensive and can be an effective means for countries to promote inclusive economic growth while increasing the value added to the forestry sector. HWP pro-duction is estimated to create between 14,000 full-time jobs in Mozambique to as many as 244,000 jobs in Viet Nam. The majority of these jobs is related to forest plantation management and thus create employment opportunities in rural areas.
The results of the study clearly show that promoting HWP helps to increase the carbon se-questration potential of the forestry sector. HWP store accumulated carbon for the lifespan of the product. Additional climate change mitigation benefits occur if HWP substitute materi-als that are greenhouse gas (GHG) intensive to produce, such as concrete or metal for construction. HWP production must be done in a sustainable manner without reducing natural forest stocks in order to ensure that the full climate mitigation potential can be realized.
Where governments seek to attract private sector investments that combine climate and forest sector benefits, investments in long-lived HWP such as wood-based panels and sawn wood offer significant opportunities. Increasing the production and consumption of HWP can accelerate meeting the objectives formulated in the countries' Nationally Determined Con-tributions (NDCs).

Harvested Wood Products, Climate Change Mitigation

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IUFRO17-2880 **The Logging Industry in the U.S. South: A Post-Recession Perspective**

Vlosky, R.* (1); Abbas, D. (2)

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Abstract: The U.S. forest industry has just come through one of the most painful economic recessions within the last 50 years. The solid wood business continues in a trough and immediate relief in housing starts is not imminent. All segments of the forest industry have been stressed since the early 2009. In this study, we surveyed 3,000 logging companies in 8 states in the U.S. South focusing on an economic assessment of their activity, status and perceptions of their future. What is known is that the general population of logging contractors has not been able to replace equipment for several years and each month logging capacity decreases as companies struggle to survive. Anecdotally, logging industry morale and outlook has been very low. This study empirically researches the situation and identifies options to recreate a viable logging business environment so that the forest based industry can avoid long-term damage to the logging node of the supply chain in the U.S. South.

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IUFRO17-2470 **Opportunities and limitations of the non timber forestal products in the participatory guarantee systems of the plurinational state of Bolivia**

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Abstract: Addressing rural poverty is one challenge of the MDG at the tropical regions where most of the incomes come from the "Entrepreneurial Crops" such as sugar cane. The entrepreneurial agriculture is predatory in matter of deforestation. Non Timber Forestal Products (NTFP) are natural resources that come from forest.
I present this study in order to answers the following questions : Which are the opportunities for the participatory certification for NTFP?, What are the limitations for the participatory certification for NTFP?
Methodology
The Value Chain Analysis (VCA) was used in this study. The tropical seeds VC is located at the Valle del Sacta University Unit which at Km 244 from Santa Cruz. 4 selected tropical seeds were selected due to their importance of handicrafts commercialized in Cochabamba. Tropical dwellers from the Valle del Sacta collect these seeds .
Actors:
A total of 20 collectors were identified, 11 processors and 2 service providers in the 4 value chains
Collectors: For the Abrus precatorius 3,Jacaranda mimosifolia 2, Chamaedora elegans 4, and Dypsis lutescens 3
Processors: For the Jacaranda mimosifolia 2, Chamaedora elegans 4 and Dypsis Lutescens 3
Consumers : At least the 73.33% are women and 26.67% men
Collectors: For the Abrus precatorius, the income was US$ 319/year, Jacaranda mimosifolia US$ 292.3/year, Chamaedora elegans US$ 259.55/year and Dypsis lutescens US$ 420/year
Processors: According to the interviews processors employ these seeds species and their incomes range from US$ 500-800/year and they sell at local fairs and the streets.
Conclusions
The processors are represented by women (average =1.5) and men (average =1.25)
Processors receive twice of the value for processing tropical seeds rather than collectors because of the value adding activities
Limitations (lack of ecologic knowledge of these species, and markets)
Opportunities (Development of a PGS seal for NTFP)

Non Timber Forestal Products, Value Chains

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IUFRO17-1961 **Brazilian international market Fairtrade products**

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Abstract: Fairtrade is an alternative model of trade that seeks equity, better conditions of exchange, and ensuring that producers and workers are paid fairly, correcting any trade imbalances and meeting the contemporary concept of sustainable development. The objective of this study was to analyze Brazilian products with Fairtrade certification in the international market, including forest-based products, in order to encourage the formulation and implementation of strategies that promote Fair Trade for forest-based products in Brazil. The methodology was based on an exploratory study in the FLO (Fairtrade Labeling Organization) database, that the countries with the largest participation in the system as well as the main products traded was grouped. The results indicate that of the 17 products listed, the countries of Africa (mainly South Africa, Malawii and Kenya) and Asia (mainly India, China and Sri Lanka) market 9, Central America and the Caribbean market 4, South America markets fruits, nuts, cereals, oils and tea. Specifically, Brazil reports that it sells coffee, orange juice, honey and fruits, only one forest-based product, a çaí. It's possible to conclude that the FLO system database has a shortage of information and that Brazil has the potential to commercialize a larger number of Fairtrade certified products.

NWFP; FOREST-BASED; FOREST CERTIFICATION

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IUFRO17-670 **Review on firm-level competitiveness in the forest sector**

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Abstract: In the future bioeconomy, boundaries between different industries and sectors will continue blurring. It is argued that the variation of individual companies within a sector can be greater than the variation between sectors in the future. The macroeconomic environment of the forest sector has attracted some scholarly attention but relatively little is known about changes in firm-level competitiveness caused by the shifting dynamics of the competitive situation.
A systematic literature review is conducted to examine how competitiveness of the sector is analyzed and what are seen as the most influential drivers of competitiveness at the firm level. The literature is analyzed regarding following three questions: 1) who competes, 2) how competitiveness is operationalized, and 3) what are the significant drivers of competitiveness.
The initial results show that the literature focuses on assessing the financial performance of manufacturing firms. The role of supporting service firms or business network structures are not well understood despite their growing role for value added creation. Furthermore, the analysis focuses on drivers of competitiveness within the sector while the evaluation of cross-sectoral competition is lacking.

competitiveness, firm, forest sector

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IUFRO17-1216 **Institutional investment in timberland, analysis of recent global trends**

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Abstract: Institutional investors started buying timberland from integrated forest companies in the US approximately in the 1970s, shedding more than 16 million hectares in few decades. Tax benefits for TIMOs and REITs and the Employee Retirement Income Security Act, 1974, prompted private pension plans and other institutional investors like endowments to diversify their holdings. During some years in the 1990s and early 2000s timberland returns outpaced nearly any other investment portfolio, however this was severely associated with a transformation of timberland into real estate as well as the purchase at very low prices.
This study analyzes the most recent data in timberland investments both in North America and internationally, its past and possible future trends. Social, economic and ethical issues related to this change in ownership and management goals are also analyzed. Although most of the investment in timberland still takes place in North America, investors, aiming to diversify their assets, have placed significant interest in other areas of the world as well, both in mature markets like Australia or New Zealand or in other emerging markets. Possibilities and constraints for a number of selected countries are studied as well.

investments, market, REIT, timberland, TIMO

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IUFRO17-2847 **Frontiers of the European forest-based sector**

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Abstract: The European forest sector is undergoing the largest changes for a century, driven by shifting global competitive advantages, consumption patterns, societal perceptions, climate and energy policies, etc. Therefore, the aim of the study is to explore; how the European forest-based sector is expected to be shaped towards 2030 and 2050, by looking at which aspects of the forest sector are likely to face the most pressure for a change and why? The study also touches upon the different ways of understanding and defining the concept of (forest-based) bioeconomy, but in the same time tries to explore the potential criteria and indicators to be used for monitoring the sustainability of the sector. A three-round Delphi survey was carried out, with a total of 41 identified experts across Europe. Based on the initial explorative interviews and a web-based questionnaire, around 40 statements were evaluated by the panel in a web-based questionnaire and commented upon during an extra round of interviews. Analysis of the results emphasizes the matters rising most controversy/disagreement, such as the possible end of the bioenergy market growth, as well as the major contradictions coming from the data, such as a stagnating industry development and biodiversity loss, yet a strong increase in wood and ecosystem services demand, but in the same time looking at possibilities for cross sectoral cooperation and general public acceptance of the changes to come.

bioeconomy; Delphi; forest sector; criteria

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IUFRO17-671 **Shared logic and customer information as means for creating value-added in wood-based residential construction**

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Abstract: Wood-based multi-storey construction (WMC) is evidently a major new business opportunity in the emerging bioeconomy in the Northern Europe. WMC benefits of the society's increasing interest toward "green" solutions in construction. However, WMC is relatively new, and the collaborative business models (ecosystems) are yet to develop. In particular, the needs of customers (investors) or residents (end-users) are decisive, but these needs may be only partially recognized. The knowledge of the customer needs may differ, or the relevant information may be insufficiently shared, and differently prioritized. This may result in customer dissatisfaction, and hinder the creation of value-added among the business ecosystem companies, or among their customers and end-users. This paper follows the concept of shared logic when analyzing a WMC building project business ecosystem in Finland, and puts particular focus on analysing information on customer/end-user needs. The study analyses how the end-user information is gathered, shared and prioritized in the decision-making processes during the various phases of the project, including potential bottlenecks. Thematic interviews of managers of the partnering companies are analysed qualitatively. The results help to understand how the ecosystem is formed and operates, and particularly how it utilizes information on customer/end-user needs for creating economic value-added.

WMC, business ecosystem, customer needs

Theme 3: Forests and Forest-Based Products for a Greener Future

32 - Perspective of short rotation forestry for sustaining society and environment

KG I - 1199 (Uni Freiburg)

IUFRO17-1413 **Early growth, survival and above-ground biomass production in vegetatively regenerated hybrid aspen (Populus tremula L. × P. tremuloides Michx.) coppice stand in hemiboreal conditions**

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Abstract: The main energy wood supply in Nordic region comes from timber processing and logging residues, however additional resources including woody biomass from intensively managed short rotation forestry (SRF) plantations could be an alternative option. Traditionally willows have been recommended for establishing SRF energy wood plantations in the region. Hybrid aspen (Populus tremula L. × P. tremuloides Michx.) as one of the most planted tree species next to willows in Nordic and Baltic countries for SRF and biomass production, can succesfully regenerate from root and stump suckers and be managed with very short rotations (3-5 years). In Estonia the establishment of hybrid aspen plantations started just 18 years ago and the experience with hybrid aspen second generation management is scanty so far. Above-ground biomass, tree growth and survival were estimated two years after the first hybrid aspen clear-cut in Estonia. On average 93 800 (range: 54 900 to 125 700) aspen shoots ha-1 had emerged after the first growing season, which had decreased to 72 300 ha-1 (range: 42 200 to 96 300 ha-1) after the end of the second year. Average tree height after the end of the second year was 2.53 m (range: 2.08 to 3.05 m). Average woody biomass of vegetative hybrid aspen stand after the second growing season was 9.0 t DM ha-1 (range 5.1 to 14.4 t DM ha-1). The current annual biomass production in the second year was 5.3 t DM ha-1 yr-1 (range: 1.8 to 10.1 t DM ha-1 yr-1). The preliminary results suggest that in favourable growing conditions unfertilized hybrid aspen could be an alternative option to willows for producing energy wood.

hybrid aspen; bioenergy; Populus; coppice forest

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IUFRO17-2515 **Canopy conformation for a greater solar radiation interception - a time-scale production system**

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Abstract: Eucalyptus spp. is the main tree cultivated essentially in extensive monocrop plantations based on a two-dimensional system (rows and lines). In another way, these enormous plantations present opportunities by integrating Eucalypt into Agroforestry Systems (AFS) in ecologically designed production systems. It is possible to use solar radiation as a main parameter for AFS design once available solar radiation is one of the most important vegetational production factors. In this manner, trees' and canopies' structure mediate the performance of the combined crops as they determine system's relation to the radiant energy. Thus it is possible to think and plan a system as a whole in view of maximizing solar radiation absorption. In this sense it was designed a tridimensional structure intermediated by a planting time scale - the fourth dimension. Since 2009 it has been carried out the Wave Project named due to the canopy wave-like appearance and the production waves spaced in time. E. camaldulensis was planted in Oct/2011 by 3x2m spacing - in: i. monocrop; ii. alley crop system with 24m spacing - Short-Wave and; iii. 42m spacing - Long-Wave. The second line of eucalyptus, closing the gap between edges, was planted in Feb/2013. The difference in height allowed a bigger canopy volume development and exposure to solar radiation with trees in Long Wave displaying 90m3 while those in monocrop presented just 22m3. This led to a higher difference on trunk diameter at breast height (DBH) between treatments - monocrop: 14.5cm; Short Wave: 18.7cm and; Long Wave: 20.3cm. It was found a good correlation between DBH and canopy volume. The use of the other two dimensions (space and time) is greatly ignored. The attempt to adjust the temporal issue with the development of the plants and the management of the system architecture presents a great possibility of increases on production and ecological adjustments still unexplored.

agroforestry; adaptation; growth; wave project

KG I - 1199 (Uni Freiburg)

IUFRO17-4155 **Planted forests in Brazil: benefits and environmental impacts**

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Abstract: The importance of forests in the landscape is evident. They play a key role in the planet's balance, either by regulating its biophysical environment, offering long-term vital ecosystem services, or by conserving biodiversity and mitigating climate change. However, in addition to the environmental aspects, it is necessary to consider the importance of social and economic components of sustainable development, for which contributions from natural and planted forests are also expected. There are numerous concepts of sustainability considered in the literature on the subject. However, all point out to the need of developing models that would be capable of using natural resources to meet the needs of society, within limits that do not endanger the quality of life of future generations. From this reasoning, two issues emerge: the ethical consumption that conserves the environment and the establishment of limits for the use of natural resources. As part of the solution for this challenge, planted forests occupy about 1% of the Brazilian territory, but have a prominent place in national exports and are now responsible for much of timber and non-timber supply for the domestic market. This study presents an approach - based on Embrapa's researchers experiences - on the potential impact of Brazilian commercial forest plantations under the perspective of different indicators. Topics such as socioeconomic and environmental importance, their insertion in the international context, impact on soil, water and biodiversity, mitigation of greenhouse gases, use of pesticides and landscape approach are discussed. The results show the importance and the evolution of the forestry sector in the pursuit of sustainability and harmony with the environment, as a component of the Brazilian rural landscape.

BRAZIL, FOREST PLANTATIONS, FOREST LANDSCAPE

Theme 3: Forests and Forest-Based Products for a Greener Future

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KG I - 1199 (Uni Freiburg)

IUFRO17-342 **Pulping potential of Corymbia citriodora, Corymbia torelliana and their hybrids**

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Abstract: This study aims at comparing *Corymbia citriodora*, *Corymbia torelliana*,(>*Corymbia citriodora* × Corymbia torelliana and *Corymbia torelliana* × *Corymbia citriodora*) for their pulp and paper making wood anatomical ratios. The material was obtained from the plantation of these species located at demonstration area of Forest Research Institute, Dehradun, India. A field trial was laid out in 2007 in RBD design. Increment cores from five sample trees of each genotype were collected at 1.37 m tree height. Radially each core was further divided into pith, middle and outer. Samples were macerated following Schultz's method. Runkel ratio (RR) values were 1.26, 0.83, 1.36, and 1.26. Shape factor (SF): 0.66, 0.57, 0.66, and 0.65. Flexibility coefficient (FC):45.34, 52.41, 45.03, 46.15. slenderness ratio (SR):64.60, 67.67, 61.85, 69.18 and Wall ratio (WR): 5.49, 4.76, 5.48 and 5.58 following an order for *C. citriodora*, *C. torelliana*, *C. citriodora* × C. torelliana and *C. torelliana* × *C. citriodora* respectively. In *C. citriodora*, SF and SR significantly varied among the trees and SR varied within the tree for radial locations. Inter-tree variations in *C. torelliana* were non- significant. An increasing trend was observed radially from pith to outwards in RR and WR of all genotypes except in *C. citriodora*. A decreasing trend from pith to outwards was observed in FC of *C. torelliana* × *C. citriodora* and *C. torelliana*. It was observed that radial variation trend showed a similar pattern for *C. torelliana* and hybrid *C. torelliana* × *C. citriodora*. All genotypes showed pulping ratios within the permissible limit for reasonable pulp.

runkel ratio, radial variation, genotype

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IUFRO17-3751 **Potential of biomass productivity of poplar (Populus spp.) cultivars in short rotations in Poland**

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Abstract: Biomass is the most important source of renewable energy in Poland. Since the use of use forest wood resources for energy production is restricted short-rotation plantations may became an alternative source of woody biomass to some extent. In this context the most promising genus in Poland is poplar (Populus spp.).
In our study ten poplar cultivars from the Aigeiros or Tacamahaca sections were compared in 5-, 6- and 7-year cycles for biomass productivity. Additional aims were to identify a suitable rotation length and evaluate the sprouting capacity of various cultivars in the climate of northern Poland.
Our results suggest that the 'NE-42' and 'Fritzi Pauley' cultivars performed best among those tested. Both of these have been tested previously in Poland in long rotations. Data for two Italian cultivars ('AF-6' and 'MON') were not analysed because of their cold-tenderness and their high mortality. Another Italian cultivar 'AF-8' had the poorest growth parameters, and produced two-thirds less dry biomass than either the 'NE-42' or 'Fritzi Pauley' cultivars. Most of tested poplar cultivars gave higher biomass productivity over cycles longer than 5 years. Our results indicate the importance of testing cultivars under local climatic conditions before planting on a commercial scale.

Biomass productivity, Poplar cultivar, NE-42

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IUFRO17-2499 **Traits to ecosystems: Linking plant traits to ecosystem processes in willow short rotation forest (ECOLINK-Salix)**

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Abstract: Enhancing favorable environmental impacts that are conducive to maintaining ecosystem functions is a main challenge in establishing sustainable forest systems. Salix grown in short rotation has high biomass production potential in many parts of the world, and may frequently support ecosystem services. Breeding programmes focus towards improving Salix productivity through selection and modification of specific traits. At present we have a poor understanding of how individual plant (e.g. Salix) genotypes or trait combinations, when added to an ecosystem, create, maintain, and change biological diversity and ultimately affect important ecosystem processes. We established three field trials with four Salix genotypes grown in monoculture and in mixture along a 1500-km gradient across Sweden and Germany in 2014 (http://www.treedivnet.ugent.be/ExpECOLINKSalix.html). In these trials, we explore how the heritable traits of some genotypes of Salix affect biomass productivity, the abundance and structure of mycorrhizal and soil fungal communities, the action of herbivorous insects and their predators, litter decomposition as well as soil carbon accumulation. Preliminary results indicate genotype-specific and mixture effects on productivity, herbivore abundance, mycorrhizal colonization and litter decomposition. The effects are discussed in the light of connecting plant traits to the relevant ecosystem processes; productivity - diversity relationships; and ecosystem services.

Biodiversity biomass genotype herbivory mycorrhiza

Theme 3: Forests and Forest-Based Products for a Greener Future

52 - Analyzing the context of energy wood production and use: policy and management approaches

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-946 **Prospects of energy wood production and use in five European countries**

Rhodius, R. (1); Peters, D. M. (1); Wirth, K. (2); Ferranti, F. (3); Frei, T. (2); Górriz Mifsud, E. (4); Krc, J. (5); Kurttila, M. (6); Leban, V.* (5); Lindstad, B. H. (7); Pezdevsek Malovrh, S. (5); Schuck, A. (8); Zadnik Stirn, L. (5)

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Abstract: The supply of and demand for energy wood in European countries is increasing mainly for reasons of policy direction to meet the European Union climate and energy targets by the year 2020. Yet increasing, the supply and demand is far from being balanced, resulting in compromised European market sovereignty and biodiversity, among other things. The following study draws some conclusions and views on the future of energy wood based on stakeholder perceptions of current political strategies, economic characteristics and forest management approaches analysed in Finland, Germany, Norway, Slovenia, and Spain. In all countries studied, the political framework as well as forest characteristics and management have been identified by stakeholders to be the most important aspects influencing current energy wood utilization. Stakeholders stressed the significant shortcomings within the political framework and considered policy measures as inappropriate, particularly concerning the supply side. Modifying forest management practices and promoting wood use in traditional forestry industries are perceived as consequences of increased demand for wood. Complex trade-offs in relation to various forest ecosystem services and between different policies would have to be solved in order to reach the targets without severe collateral effects on the economy and the environment.

mixed research design, drivers of change

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1412 **Cross-sectoral perception of the operational environment of forest bioenergy production and use in four European countries**

Pezdevsek Malovrh, S.* (1); Kurttila, M. (2); Hujala, T. (3); Kärkkäinen, L. (2); Leban, V. (1); Lindstad, B. (4); Solberg, B. (4); Peters, D. M. (5); Rhodius, R. (5); Wirth, K. (6); Zadnik Stirn, L. (1); Krc, J. (1)

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Abstract: This study evaluated the operational environments of strategies related to increased forest bioenergy targets in Finland, Germany, Norway and Slovenia. A mixed-methods analysis of the operational environments was carried out by combining a SWOT analysis and the SMART technique. To enable comparison between countries, four pre-set operational environment categories (Forest Characteristics and Management, Policy Framework, Technology and Science, and Consumers and Society) framed the analysis. In workshops stakeholders defined and weighted the factors that affect the operational environments separately for two future scenarios, one reflecting the current 2020 targets, and the other reflecting a further increase in targets. The results show that the greatest differences between the scenarios appear in Germany, indicating a notably negative outlook for the increase scenario, while the smallest differences were found in Finland. In Slovenia the increase scenario contains higher weights for strengths and opportunities, while in Norway the outlook is nearly as negative as in Germany. Policy Framework was a highly rated category across the countries, mainly with respect to weaknesses and threats but also for strengths in Germany and opportunities in Finland and Norway. Intensified forest bioenergy harvesting and utilization has potentially wide country-specific impacts which need to be anticipated and considered in national policies and public dialogue.

Biomass Production, Stakeholder Perception

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-313 **Possibilities to increase energy wood production: a case study on forest policy-practice interface in selected European countries.**

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Abstract: European Union's policies foster an increased reliance on energy wood from forests. This study analyzed whether such policy ambitions found a correspondence with perspectives of national stakeholders who deal with the everyday practice of energy wood production. A qualitative approach was applied to analyze this correspondence by enquiring opinions of stakeholders from three case study countries (Germany, Slovenia and Spain) on current and future roles of energy wood and potential to increase energy wood production, as well as on possibilities to apply three concrete options for increasing such production. Stakeholders' perspectives coincided with European Union's discourses regarding the role of energy wood in boosting the competitiveness of the forest sector and contributing to climate change reduction. In order to motivate an increased reliance on energy wood and achieve European Union's goals, policy makers should base their strategies on these positive considerations on the role of energy wood. However, important trade-offs were associated by stakeholders to increased energy wood production and hindered the possibility to pursue such increase in the national contexts. In order to improve feasibility of an increased reliance on energy wood, these trade-offs should be solved at supranational level by prioritizing policy objectives which affect the environment.

European policy, bioenergy, stakeholders

Theme 3: Forests and Forest-Based Products for a Greener Future

52 - Analyzing the context of energy wood production and use: policy and management approaches

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IUFRO17-429 **The effect of energy wood production and use on other forest ecosystem services - stakeholders' perceptions in five European countries**

Wirth, K.* (1); Peters, D. M. (2); Böhr, B. (3); Ferranti, F. (4); Górriz Mifsud, E. (5); Kärkkäinen, L. (6); Krc, J. (7); Kurttila, M. (6); Leban, V. (7); Lindstad, B. H. (8); Pezdevsek Malovrh, S. (7); Pistorius, T. (9); Rhodius, R. (10); Solberg, B. (8); Zadnik Stirn, L. (7)

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Abstract: Over the past decade, forest energy wood has become an increasing important product in the forest sector. The objective of this study was to provide a qualitative analysis of stakeholders' perceptions of current and future trade-offs as well as synergies between energy wood production and use and other ecosystem services. We developed an explorative research approach and conducted semi-structured interviews with six selected stakeholder groups in Finland, Germany, Norway, Slovenia and Spain. Stakeholders generally perceive a strong synergy with employment whereas trade-offs regarding conservation of biodiversity are the most critical issue related to energy wood production in forests. Looking at differences between countries, Spain as the only mediterranean country stands out with different issues discussed and more synergies perceived by stakeholders, compared to all other countries, where the issues discussed are more homogenous and include a greater focus on trade-offs.. To address current and future trade-offs and to tap into the full potential of synergies, effects of energy wood production and use should be taken into account in policy development and forest management. Different characteristics of countries and regions need to be considered, and decisions need to be fostered by long-term and far-reaching political frameworks.

Bioenergy;ecosystem services;social sciences;wood

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1418 **Can private forest owners contribute to Wood Mobilisation? Case study on Croatia, Serbia, Bosnia and Herzegovina, FYR of Macedonia**

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Abstract: Sustainable forest management requires long term planning, investment in biological reproduction, rational utilization, and satisfaction of needs of present and future generations, what is especially important for small scale private forest owners. The selected countries are starting to face the problem of lack of raw material for the wood processing industry and new cogeneration plants for energy production. Due to the older population trends, small size economy, fragmented parcels, lack of equipment or other factors, owners are not motivated for active forest management and biomass production. One of the the solutions to this problem, could be establishment of private forest owners associations and their practical education for better use of forest resources.
With different methodology approaches like smart regulation, there is need to understand forest owners' characteristics, their objectives and property characteristics, to analyze conditions when they would be ready to produce woody biomass and finally which are the obstacles and policy instruments for promotion of woody biomass utilization from private forests in SEE region. The case study will analyze research results from collected data among private forest owners questionnaire in five selected countries, and propose the future steps which need to be taken in order to motivate the private forest owners for woody mobilization.

woody biomass, mobilization, smart regulation

KG II - Auditorium Maximum (Uni Freiburg)

IUFRO17-1421 **Factors and trends in the production and use of woody biomass: a case study of Slovenia**

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Abstract: The following study examines the development of energy sector and Renewable Energy Sources (RES) from woody biomass in Slovenia since the mid 1990s. We assessed the conditions at two points in time, 1995 and 2013. The study sought to answer the following questions: (a) What differences occurred in the supportive environment in both periods in the light of RES development?; (b) How does the potential to increase the share of RES in the Slovenian energy balance differ among the periods examined?; and (c) What is the understanding of the role of forest management in the field of woody biomass from forests? The analysis reveals that all the values of selected indicators of the primary and final energy use increased. Noticeable, the import and export indices increased by several times, and the share of RES and the share of biomass in the total Slovenian energy consumption almost doubled. Nevertheless, the percentage of biomass within the RES did not increased equivalently. The comparison of SWOT analyses for both periods highlights the factors that affected the success in the interim period, and, at the same time, points to the latent conditions or new challenges connected with the use of woody biomass.

renewable energy sources, comparative analysis

Theme 3: Forests and Forest-Based Products for a Greener Future

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IUFRO17-1507 **Evaluation of indicators that affect the utilization of wood for energy, case of municipality Sentjur, Slovenia**

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Abstract: The importance of renewable energy, among which wood from forests is a significant component, has increased drastically in the last decade. Given the current global interest and policies related to energy and climate, this importance will continue to rise. Most of the existing research has a national or international focus, while this presentation examines the availability of wood for energy in a municipality to provide heating for public facilities and households, as well as for industries in the municipality, in the light of self-supply. The research methodology includes guidelines for obtaining key parameters related to the availability and utilization of wood as an energy source in the municipality from the Statistical Office of the Republic of Slovenia; Slovenian Forest Service; and from forest management plans, forest inventories, realization of harvest, local energy concepts, and surveys. We also describe qualitative/quantitative analytical methods in which the problem of influential factors affecting energy wood production and use in a municipality is modelled considering different scenarios related to felling. The factors are organized as SWOT factors and are ranked by experts through surveys which are analyzed using the group AHP method. The methodology is applied to a case study of Sentjur, Slovenia.

wood for energy, municipality, SWOT, AHP, Slovenia

Theme 3: Forests and Forest-Based Products for a Greener Future

75 - The nexus between bioeconomy and forest biomass: Challenges, opportunities and necessary steps in

KG I - Aula (Uni Freiburg)

IUFRO17-3939 **Bioeconomy and the City**

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Abstract: With 50% of the global population living in urban areas, cities are transforming into hotspots for future global demand in terms of food, water and energy. Developing new and efficient forms of a low-carbon society will gain in importance. Biomass - mainly from urban forests - but also residues and waste from parks, gardens and agricultural area could contribute substantially to a local low-carbon bioeconomy including energy supply, construction material, and new (by)products such as biofuels. Yet urban ecosystems also provide other services that have to be balanced against future bioeconomy needs. Bioenergy, as a substantial part of the bioeconomy, plays an important role in mitigating dangerous climate change and will therefore most likely have to further expand substantially. This study conducts a first geo-spatial analysis of urban forests and other productive land uses with respect to its potential to feed the urban bioeconomy. At the same time, social and environmental constraints are considered and co-benefits discussed. In order to test the wider applicability of the methodology, the Vienna Woods Biosphere Reserve is chosen as a case study to determine the feedstock potential for local bioenergy provided to Viennese households. The potential is modeled and then compared to the existing production area using GIS tools. Results show that the biomass harvesting within the biosphere reserve can be increased by about 60%, while acknowledging multiple ecosystem services provided by the reserve. This indicates a high potential of peri-urban ecosystems to contribute to urban bioeconomy feedstock and urban resilience - i.e. with respect to energy security and emissions reduction.

Urban biomass, bioeconomy, bioenergy

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IUFRO17-2467 **An Overview of Wood-based Energy in North America**

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Abstract: Historically, global energy consumption has been dominated by non-renewable fossil fuels such as oil, natural gas and coal. Alternative renewable, non-extractive sources of power, such as wind and solar, have gained momentum in growth. In addition, over the past two decades, there has been significant and growing attention globally to what is general termed the "Advanced Bioeconomy". This includes research, development, and commercialization in the use of cellulosic materials to create new fuels, feedstock for electricity generation, and other value-added co-products and materials. The development of the nascent bioeconomy is primarily driven by a desire to reduce global greenhouse gas emmissions such as carbon dioxide(CO2), nitrous oxide (N2O) and methane (CH4). This presentation will focus on wood-based renewable energy in North America. Topics include the current landscape, sources of woody biomass, and options for wood-based bioenergy and biofuels. In addition, the drivers for this emerging sector as well as successes and failures will be examined. Although the focus is North America, the Advanced Bioeconomy is global and many of the lessons learned in North America have implications in other regions and countries.

Wood-based, bioenergy, North America

KG I - Aula (Uni Freiburg)

IUFRO17-1997 **Sustainable Forest Biomass: Promoting Renewable Energy in Forest Sector of Myanmar**

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Abstract: In Myanmar, about 70% of the population of the country lives in the rural area and greatly rely on biomass energy especially for cooking. It is the main reason of causing high biomass energy share in energy mix which is as much as 65% of the total energy consumption in the country. Owing to the high utilization of biomass energy resources, Myanmar is facing the challenges of high deforestation rate which is about 0.55% annually. Forestry sector is supplying the energy requirement of the country through provision of firewood/charcoal from its renewable forestry resources. Therefore, it is urgently needed to promote the renewable energy in forestry sector of Myanmar through sustainable forest management (case study in Sagaing, Mandalay, Magway, Ayeyarwaddy and Shan).
This paper highlights how forest sector is managing sustainably on both government and private lands to generate this excess woody material that can be put to productive use for both products and energy by using modern technologies thus, providing economic incentives to maintain forestry investments. Moreover, the paper also points out the importance of woody biomass for ecological functions such as soil organic matter, nutrient cycling, hydrological functioning, and coarse debris of wildlife habitat.

Modern technology,biomass, Ecological function.

Theme 3: Forests and Forest-Based Products for a Greener Future

75 - The nexus between bioeconomy and forest biomass: Challenges, opportunities and necessary steps in

KG I - Aula (Uni Freiburg)

IUFRO17-2827 **Energy from forest biomass in Austria**

Jandl, R. (1); Bruckman, V.* (2)

(1) Austrian Forest Research Center, Vienna, Austria; (2) ÖAW, Vienna, Austria

Abstract: The Austrian forest can substantially and sustainably contribute to the provision of renewable energy. The energetically useable material derives from residues from thinning operations, salvaged timber after storms and to a large degree from timber processing. Other sources of energetically useable biomass are scarce because the agricultural sector is placing its potentially available biomass on other markets. Particularly in rural areas the forest biomass can ensure almost energy autarky. However, there are several obstacles: (i) under the prevailing low oil prices it is difficult to competitively generate energy derived from forest biomass. (ii) Burning of wood leads to the emission of fine particulate matter. The problem is solved in modern burners. However, many ovens are not equipped with the latest technology. (iii) The production of fuel wood as primary use of timber is increasingly scrutinized. In order to meet the highly ambitious goals of climate protection the energy supply from forests is expected to play a relevant role.

fuel wood, particle emission, sustainability

KG I - Aula (Uni Freiburg)

IUFRO17-2736 **Overmature periurban Quercus-Carpinus coppice forests in Austria and Japan: a comparison of carbon stocks, stand characteristics and conversion to high forest**

Bruckman, V. J.* (1); Terada, T. (2); Fukuda, K. (2); Yamamoto, H. (2); Hochbichler, E. (3)

(1) Austrian Academy of Sciences, Commission for Interdisciplinary Ecological Studies, Vienna, Austria; (2) The University of Tokyo, -, Japan; (3) University of Natural Resources and Life Sciences (BOKU), Vienna, Austria

Abstract: Periurban coppice forests have a long history and tradition in Austria, as well as in Japan. Although developed in a slightly different context, such forests faced nearly the same fate during the last century. While these once served biomass almost exclusively as a feedstock for thermal energy, their significance decreased with the increasing use of fossil fuels and coppice management was consequently abandoned, or these forests were converted into high forests with different management aims. This study tries to assess the status of periurban forests that were previously managed as coppice in a comparative approach between Vienna (Austria) and Tokyo (Japan) in view of rising demands for biomass. The focus is to present stand structure, biomass and C stocks, as well as a comparison with high forest in typical stands close to the urban area. In Japan, we further directly assessed the consequences of coppice to high forest conversion on soil chemistry. While lower diameter classes are dominated by Carpinus, Quercus is only found in larger diameter classes, indicating the overmature character of both stands due to the lapse from a recognized system of coppice management with occasional fuelwood harvesting in the past decades. Total C stocks are comparable, but soil organic carbon (SOC) is significantly higher in Japanese Andosols. The conversion of coppice to high forest in the 1960's in Japan had a notable impact on soil chemistry in our plots. There may be multiple benefits for restoring coppice management to these periurban forests. This includes increased biomass production capabilities and carbon sequestration as well as a better habitat provision and a higher biodiversity.
This paper was recently published in Eur J Forest Res (135:857-869).

Coppice, biomass, carbon stocks, forest soil

KG I - Aula (Uni Freiburg)

IUFRO17-825 **Production of bioethanol from residues of coffee wood (Coffea arabica L.) in Viotá, Cundinamarca, Colombia**

Gómez, S. A.* (1); Gómez, M. E. (2); Huertas, K. A. (1)

(1) Universidad Distrital Francisco José de Caldas, Bogotá, Colombia; (2) Universidad Católica de Colombia, Bogotá, Colombia

Abstract: Coffee in Colombia is one of the most important crops for the country's economy. Currently, there are 940919ha of coffee in the country and every 7 years all the trees of this age are felled and new seedlings are planted instead.

In the province of Viotá there are close of 200ha of coffee for felling per year, equivalent to about of 3200 tons of wood and 932826 liters of Bioethanol. The wood resulting from this process has no specific utility and is burned or discarded as trash more frequently.

Wide researches have proven that it is possible to produce bioethanol from lignocellulosic organic matter. The method used in this project is steam explosion, hydrolysis and fermentation, in which, conditions of high pressure and temperature in a chamber are simulated. Suddenly, the pressure drops to atmospheric pressure, causing an explosion leaving the sugars free to ferment and distil.

The production of Bioethanol from coffee wood provides a positive impact for the coffee peasant population of the province of Viot á because it generates economic income from the sale of wood, which used to be a waste or trash; They also benefit from the inclusion of cheaper and cleaner fuels than fossil fuels in their production systems.

Bioethanol, Coffee Wood, rural economy

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

11 - Progress in tropical forest management: Assuring sustainability, avoiding degradation and assisting

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2829 **Timber production, logging residues, and forest recovery of Brazilian Amazon rainforest: nine case studies of different managed forests.**

Numazawa, C.* (1); Numazawa, S. (2); Pacca, S. (1); John, V. M. (1)

(1) University of Sao Paulo, São Paulo, Brazil; (2) Federal Rural University of Amazon, Belém, Brazil

Abstract: Forest management systems must assure the production of forest products while maintaining environmental services, and provisions in the Brazilian Forest Code support sustainable logging practices. Selective timber harvesting is frequently cited as a sustainable use of tropical forests, which is an important income source for local dwellers, however, most commercial wood species occur at low densities (<1 adult tree ha-1). Considering that the reduction of collateral damage (biomass that is left on the field decomposing and releasing carbon) reduces land degradation and forest restoration time, this paper aims to investigate the potential of sustainable forest management to minimize collateral damage (CD). Based on original data collected from nine logging areas in the state of Par á, Brazil, we determined the yield effectiveness (EF) of areas subject to harvesting intensities (HI) between 15-29 m³ ha-1. The bole of a typical tree corresponds to 66% of its total mass, which is therefore considered as the maximum EF. The EF is calculated as the amount of bole yield divided by total biomass destroyed divided by the maximum EF. The EF of 15 m³ ha-1 HI (above ground standing biomass (AGSB) of 226 t ha-1) was 50% and the highest EF was 56% over 27 m³ ha-1 HI (AGSB of 165 t ha-1). Thus, EF was related to AGSB and the technology applied, and not to HI. We have found that under HI up to 15 m³ ha-1 full biomass recovery was achieved. Consequently, sustainable management of tropical forests must rely on appropriate harvesting technologies and appropriate limits in order to sustain forest productivity and biodiversity. Brazilian forest regulations should take these findings into account.

logged forest; residues; forest restoration

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1187 **Methodological approaches and preliminary results of forest biomass measurements for the implementation of the REDD+ mechanisms in the COMIFAC area**

Medjibe, V. D. P.* (1)

(1) COMIFAC, Yaounde, Cameroons

Abstract: To take advantage of the REDD+ mechanisms, the Congo Basin countries must overcome significant institutional and technical capacity challenges. They have a strong rationale for addressing these challenges with a joint regional approach.
Supporting the Congo Basin countries in their joint regional approach to REDD+, the World Bank, with the grant from the Global Environmental Facility to the Central Africa Forests Commission (COMIFAC), aimed to strengthen countries' capacities to meet the institutional and technical prerequisites necessary to benefit from the REDD+ incentive mechanisms. The benefice of the REDD+ mechanism requires the country capacity to provide estimates of carbon emission factors, the reference emission levels, and the monitoring, reporting and verification system. The overarching challenge of these countries is the availability of appropriate allometric equations to estimate forest biomass.
The inventory of allometric equations has highlighted their scarcity in sub-region. To fill this gap, the Central African regional REDD+ project is being conducted biomass data collection within the six most forested countries to develop country specific and regional forest biomass allometric equations. The goal of this presentation is to introduce the methodological processes of biomass data collection and to discuss the preliminary results at both the national and regional scales.

Congo Basin, COMIFAC, REDD+, Allometric equations

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3310 **Simulation of tropical forest management in a spatially explicit global forest model**

Gusti, M.* (1); Pietsch, S. (1); Kindermann, G. (1); Kraxner, F. (1); Forsell, N. (1); Havlik, P. (1); Mosnier, A. (1)

(1) International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

Abstract: Tropical forests contain hundreds of tree species, only some of which are harvested for commercial timber production. FAO recommends using of polycyclic or monocyclic silvicultural systems for sustainable timber production in tropical forests. Some models allow adequate simulation of different forest management regimes at the local scale, e.g. SORTIE-ND, DIPSIM or models by Phillips et al. (2004), Orellana et al. (2016). For universal global forest simulation models, however, the representation of different types of forest management remains a challenge.
The global forest model G4M operates on 0.5x0.5 degree regular grid. In each grid cell a forest simulator (FS) is applied. The FS tracks area, biomass, and diameter of stands of different age classes, transitions between the age classes during every modelling time step, and considers prescribed harvest and restoration, as well as afforestation and deforestation events. Biomass and diameter increments are estimated using growth functions parameterized to data obtained from forest yield tables or specific forest growth models together with grid-cell specific mean annual increment (MAI) estimates. In the global version of the model two types of tree species are considered: fast growing and slow growing. Area of the age classes can change due to logging, replanting or regeneration after logging, and due to afforestation and deforestation events. The FS can estimate the rotation age (felling cycle in case of polycyclic silvicultural systems) and chooses between maximizing MAI or forest biomass. The age classes of the forest stands can correspond either to real even age stands or to virtually sorted trees of an uneven age forest. We show how tropical forest management aimed at FAO-calibrated wood production may be represented within an existing FS and will present solutions to improve simulation results.

simulation, forest management, wood, global model

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

11 - Progress in tropical forest management: Assuring sustainability, avoiding degradation and assisting

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3790 **Implications of changes in tropical shifting cultivation intensification on future GHG emissions in the Congo Basin**

Bustier, B. (1); Ngoy, A. (2); Koundou, B. (3); Minko, M. (4); Moutsinga, J.-J. (5); Mosnier, A.* (6); Pirker, J. (6); Havlík, P. (6); Kraxner, F. (6)

(1) MSDN, Libreville, Gabon; (2) IRET, Libreville, Gabon; (3) IRAF, Libreville, Gabon; (4) COAFNO, Aboun, Gabon; (5) SDP, Libreville, Gabon; (6) IIASA, Laxenburg, Austria

Abstract: Traditional shifting cultivation used to be a sustainable type of land use for the subsistence of populations in tropical rainforests. The vast resource of moist tropical forests together with low population densities allowed for long fallow periods on sparsely distributed slash and burn parcels with large areas of untouched forest in between. Population growth and concomitant increase in land demand for subsistence as well as increasing infrastructure development for commercial forestry, cash crops and mining, however, altered the picture over recent decades. As a result, fallow periods were reduced due to lack of pristine land. In this study we use field data and modeling results from the Congo Basin to assess the impacts of reduced fallow periods on Carbon sequestration dynamics using a BGC model calibrated and validated with > 150 research plots distributed over the western Congo Basin and representing different management and land use histories. We find that the average carbon sequestration rate reduces over the number of cultivation cycles and that a reduction of the fallow from 10 years to 7 years reduce the average carbon sequestration between 13 and 21% and from 7 years to 4 years between 23 and 29% depending on soil fertility. We then use these results to estimate the overall impacts of different development trajectories on GHG emissions from land use and land use change in the Congo Basin for the next decades with the GLOBIOM model, an economic partial equilibrium model which represents the main land-based sectors. We show that the fact that carbon sequestration on fallow land is not taking into account in many models leads to an overestimation in future emissions in the Congo Basin and tends to overestimate the negative environmental impacts of shifting agriculture, especially when fallow is long.

shifting agriculture, Congo Basin, deforestation

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2333 **Sustainable woodland management and livelihood options in a charcoal producing region: an agent-based modelling approach**

Kiruki, H.* (1); Van der Zanden, E. (2); Verburg, P. (2)

(1) South Eastern Kenya University, Vu University, Amsterdam, Netherlands; (2) Vu University, Amsterdam, Netherlands

Abstract: Woodland resources provide livelihoods for millions of people in Africa. Concerns about the impact of human utilization of woodlands have led to vigorous debates on woodland degradation. Based on previously collected ecological and socio-economic information, we explore different sustainable woodland management options for a semi-arid region in Kenya using an agent-based modeling (ABM) approach. Satellite image analysis of this area shows a rapid loss of woodlands, mainly due to charcoal production. Using an ABM approach, we are able to simulate the impact of different land management options under varying economic conditions and policy arrangements for a 20-year period in a spatially explicit way.

Within the modeling framework, we use an agent typology to include the diversity of household incomes and decision-making strategies. The typology is based on 295 household interviews that focused on livelihood strategies and decision-making under different scenarios. To incorporate key drivers of woodland degradation, we use information from an assessment on the effect of key woodland degradation drivers (i.e. charcoal production, shifting cultivation and livestock grazing) on different woodland indicators. This assessment, based on 71 sample plots, showed that species diversity, tree density and biomass decrease with increasing agricultural intensity and charcoal production in this area.

livelihoods; species diversity; land-use; Kenya

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3905 **The Tropical managed Forests Observatory: a research network addressing the resilience of tropical logged forests**

Sist, P.* (1); Hérault, B. (1); Rustishauser, E. (2)

(1) Cirad, Montpellier, France; (2) Smithsonian tropical research Institute, Panama City, Panama

Abstract: While attention to logging in the tropics has been increasing, studies on the long-term effects of silviculture on forest dynamics and ecology remain scare and spatially limited. Indeed, most of our knowledge on tropical forests arise from studies carried out in undisturbed tropical forests. This bias is problematic given that logged and disturbed tropical forests are covering now a larger area than the so-called primary forests. A new network of permanent sample plots in logged forests, the Tropical managed Forests Observatory (TmFO), aims to fill this gap by providing unprecedented opportunities to examine long-term data on the resilience of logged tropical forests at regional and global scales. This presentation aims to introduce the TmFO which currently includes 22 experimental sites distributed across three tropical regions, with a total of 452 permanent plots and 880 ha of forest inventories. We will present here the main objectives and research questions of TmFO as well as its main results on the long term impact of logging on Carbon fluxes and biodiversity. from these results innovating silvicultural practices will be presented

Resilience, Tropical Forests, silviculture

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

16 - Joint management of large herbivores and forests for resilient ecosystems

K 1 (Konzerthaus Freiburg)

IUFRO17-1534 **Interactions between ungulate herbivores and forest management and the search for resilient forests in western North America**

Endress, B.* (1); Wisdom, M. (2); Defrees, D. (1); Averett, J. (1); Naylor, B. (2)

(1) Oregon State University, La Grande, United States; (2) Pacific Northwest Research Station, USDA Forest Service, La Grande, United States

Abstract: Herbivory by ungulates can affect the structure, composition, function and dynamics of nearly every terrestrial ecosystem in the world. High numbers of both domestic (cow) and wild (elk, deer) ungulates are found throughout the semi-arid conifer forests of western North America. Despite high densities, the role of domestic and wild ungulates in influencing forest dynamics, resiliency and health remains poorly understood. In particular, the degree to which ungulate herbivores can exert influence on forest ecosystems under different forest management activities, such as timber harvest and fuels reduction treatments, is unclear. In this presentation, we will share new data and integrate and synthesize a decade of research examining these issues in the interior Pacific Northwest of the United States. Results indicate (1) western landscapes are exposed to high levels of ungulate herbivory, (2) the strength of herbivore effects varies depending on forest management activities, and (3) recent efforts to increase the scale and scope of fuels reduction activities to reduce wildfire risk may exacerbate ungulate impacts, delaying recovery of the understory, resulting in homogenized forest stands that lack structural complexity with reduced value for both wildlife and livestock. In order to increase forest resiliency, integrated approaches that acknowledge and account for interactions between ungulates and forest management activities must be developed. For example, ensuring forest stands maintain structural elements in the understory that act as refugia (e.g. coarse woody debris) for highly preferred plant species following management activities may increase forest complexity and stand resiliency.

Herbivory, Ungulates, Fire, Silviculture, Grazing

K 1 (Konzerthaus Freiburg)

IUFRO17-1891 **Reindeer hinder restoration benefits in boreal forests**

Tarvainen, O.* (1); Hekkala, A.-M. (2); Miller, S. (3); Tolvanen, A. (1)

(1) Natural Resources Institute Finland (Luke), Oulun yliopisto, Finland; (2) SLU, Department of Wildlife, Umeå, Sweden; (3) Bournemouth University, Dorset, United Kingdom

Abstract: Prescribed burning is used to create deadwood and restart succession in order to diversify forest structure. Grazing also affects forest structure and vegetation composition, but the interaction of grazing with burning in boreal forests is not well understood. In northern Finland, an area of mixed boreal forest was designated for an experiment into the impacts of burning and grazing on forest composition. Surveys were undertaken of vegetation composition and new tree seedling establishment before (2005) and regular intervals after restoration (2007 - 2015). The results showed that burning had the stronger impact of the two disturbances, increasing forest floor diversity. Burning either increased or decreased most vegetative functional groups' cover, while grazing only decreased the cover of epigeous lichens. Burning also had the desired effect of enabling new tree seedling establishment, whilst grazing hindered the growth of aspen. With European aspen a priority species in Finland, regeneration of aspen is a specified aim of some forest restoration programmes. In order to maximise the success of these programmes, the results from this study suggests grazing should be restricted from newly burned areas to support new aspen seedling establishment.

aspen, grazing, reindeer, restoration. vegetation

K 1 (Konzerthaus Freiburg)

IUFRO17-564 **Impact of ungulates on regeneration in Switzerland depends on forest type**

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(1) Swiss Federal Research Institute WSL, Forest Resources and Management, Birmensdorf, Switzerland

Abstract: Terminal shoots of tree regeneration are part of the diet of chamois, roe and red deer, which in turn can affect forest regeneration. Depending on the forest type the ungulates prefer different tree species and parts and thus may have varying impacts on the development of the natural tree regeneration. We investigated the extent of browsing influence on regeneration in various forest types that differ in climate and soil properties.
We were particularly interested in the relative influence of browsing on tree regeneration compared to other site factors. On 15-64 permanent plots in each of 66 study areas in Swiss forests, saplings were repeatedly assessed for browsing. Between 2012 and 2015 site-specific characteristics such as developmental stage, light, soil pH were measured in all plots and the saplings' growth rate was determined.

Browsing was among the most important variables explaining size-dependent species composition. More tall than small seedlings of *Fagus* and *Fraxinus* were present, but an inverse pattern was found for *Abies, Acer, Sorbus* and *Picea* due to browsing. In relation to other variables, such as basal area, light and slope, browsing was less crucial for explaining sapling density, but all species declined in density if annual browsing exceeded a threshold value of about 5-10%, while above this threshold no further change was observed. This non-linear relation was based on the fact that in some areas already very low browsing intensities caused large impacts on natural tree regeneration, while in other areas high numbers of trees were present in all height classes, despite high browsing intensities. Browsing severity as well as site-dependent seedling establishment and growth caused such site-specific differences.

Well and diverse regenerated and well growing stands support higher densities of ungulates than slow growing mountain forests. Site-specific management of both ungulates and forests are thus most promising for resilient ecosystems.

Game browsing, herbivory, natural regeneration

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

16 - Joint management of large herbivores and forests for resilient ecosystems

K 1 (Konzerthaus Freiburg)

IUFRO17-358 **Evaluation of the impact of sika deer on natural forests using a simple check list**

Akashi, N.* (1)

(1) Hokkaido Research Organization, Forestry Research Institute, Bibai, Japan

Abstract: To evaluate the impact of deer on natural forests on a regional scale, a simple and objective method is required that many people can apply. We conducted a survey in Hokkaido, Japan using a simple check list that include six items: 1) bark-stripping; 2) browsing scars on trees; 3) browsing scars on dwarf bamboo; 4) deer track; 5) footprints; and 6) feces. The check lists were completed by many foresters, forest managers and researchers at 1,949 sites in 2015. The results of a multiple correspondence analysis (MCA) for the six items suggested that each site could be plotted on a coordinate with three directions indicating that the impact was high, low, or unknown. The primary factors in the scoring of sites were correlated with sightings of deer per unit effort by hunters. The impact of deer on whole natural forests in Hokkaido was estimated using Kriging the primary factor of MCA at each site, and the result was considered sufficiently valid, compared with existing information. The result represents not only the high-impact area but also areas of relatively minor impact, and provides useful information for the management of the deer population at an early stage of increase.

sika deer, multiple correspondence analysis

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

11 - Progress in tropical forest management: Assuring sustainability, avoiding degradation and assisting

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1228 **Forest resilience to silvicultural interventions in a tropical rain forest of the Brazilian Amazon**

de Avila, A. L.* (1); Ruschel, A. R. (2); Mazzei, L. (2); Silva, J. N. M. (3); de Carvalho, J. O. P. (3); Dormann, C. F. (4); Bauhus, J. (1)

(1) Chair of Silviculture, University of Freiburg, Freiburg im Breisgau, Germany; (2) Embrapa Amazônia Oriental, Belém, Brazil; (3) Federal Rural University of the Amazonia, Belém, Brazil; (4) Biometry and Environmental System Analysis, University of Freiburg, Freiburg im Breisgau, Germany

Abstract: Sustainable forest management requires that forest ecosystems will recover their functions across felling cycles. So far, our understanding of tropical forest resilience to silvicultural interventions is rather limited, especially regarding multiple functions and the medium to long-term post-logging recovery. Here, we investigated how silvicultural intervention intensity affected recovery of important forest attributes and functions related to biodiversity conservation, carbon sequestration and timber provision over a period of 30 years after initial logging. We analysed data from a unique long-term experiment located in the Tapaj ós National Forest, Pará, Brazil, where trees greater or equal than 5 cm DBH were measured on 8 occasions in 41 permanent sample plots including natural forest. Disturbance intensities comprised logging (1982) with associated damage and follow-up thinning (1993-1994). An important finding was that the recovery of tree species composition, biomass and timber stocks was impaired when basal area was reduced by more than 20% relative to pre-logging stocks. Conversely, recovery in tree species diversity was not impaired by intervention intensity. Within the period of monitoring, no critical threshold in intervention intensity was observed that caused a loss of regenerative capacity. However, further monitoring is required to inform about the long-term recovery of forest attributes such as commercial timber stocks.

biomass, thinning, diversity, composition, timber.

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3341 **Changes in rainforest dynamics under different management regimes**

Pietsch, S. A.* (1); Ngomanda, A. (2); Nziengui, M. (3); Tanga, J.-J. (4); Ngok Banak, L. (2); Bednar, J. (1); Gautam, S. (5)

(1) IIASA, Laxenburg, Austria; (2) IRET, Libreville, Gabon; (3) ENEF, Cap Esterias, Gabon; (4) CNPN, Libreville, Gabon; (5) BOKU, Vienna, Austria

Abstract: Tropical forests differ from mid-latitude, temperate and boreal forests due to their high heterogeneity and species diversity. Among the tropical forests, moist and wet forests exhibit the highest tree species diversity and contain commercially highly valued timber. The density of exploitable stems per hectare, however, is normally restricted to 2-5 stems. Any timber exploitation is, hence, concomitant with damage and/or death of neighboring trees and with the removal of several trees to gain access to the marketable timber resource. Depending on the type of forest exploitation concession, i.e. permanent, medium or short term, different harvesting and timber extraction strategies are applied.
Within this study, the different strategies will be analyzed for their sustainability in terms of Carbon stocks, Carbon sequestration, growth dynamics and the prevalence of commercially valuable species, using a BGC-model calibrated and validated with field data from > 150 field plots distributed over the western Congo basin and representing different management and land use histories.
Results indicate that non-linear forest growth responses may alter expected Carbon stocks and sequestration potentials. Sudden shifts in forest growth dynamics may occur which in turn may have opposing impacts on the occurrence of commercially important timber species.

ecodynamics, management, tipping point, field data

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2316 **Diameter-Limit-Tables as a basic silvicultural tool for the sustainable management of Fijian rain forests**

Mussong, M.* (1); Senivasa, E. (2); Mateboto, J. (3); Fedlmeier, C. (4)

(1) Eberswalde University for Sustainable Development, Eberswalde, Germany; (2) Ministry of Forests, Suva, Fiji; (3) Secretariat of the Pacific Community, Narere, Fiji; (4) Deutsche Gesellschaft für Internationale Zusammenarbeit, Narere, Fiji

Abstract: As a basic silvicultural tool for sustainable management of tropical rainforests in Fiji a species-specific felling diameter limit system (DLT) for 3 different harvesting intensities was developed in the early 1990th. The DLT was implemented in 7 compartments of a pilot area removing 1/6 ("light logging"), 1/3 ("medium") and 1/2 ("heavy") of the standing volume 35 cm dbh. For comparison purposes another 2 compartments were logged according to the existing regulations ("conventional") with an overall felling limit of 35 cm dbh (leading to corresponding removals of ca. 80-90 %) and 3 compartments were kept untouched. Twenty years after the intervention a forest inventory indicates that medium and heavy intervention show a higher net volume increment than the conventionally logged compartments. There is no indication that tree species have disappeared due to logging but the share of undesired (non-commercial) species has increased significantly in the conventional and heavy logged compartments. The total carbon stock after light and medium intervention is only slightly below (-3 %) the carbon stock of the unlogged compartments while the conventionally logged compartments bear 23 % less carbon. Therefore, the light and especially the medium DLT intervention are suitable for integration in a REDD+ strategy.

tropical silviculture, diameter limit system, REDD

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

16 - Joint management of large herbivores and forests for resilient ecosystems

K 1 (Konzerthaus Freiburg)

IUFRO17-776 **Reconciling forest production and hunting in adaptive management - French case studies**

Mårell, A.* (1); Hamard, J.-P. (1); Boscardin, Y. (1); Rocquencourt, A. (1)

(1) Irstea, Nogent-sur-Vernisson, France

Abstract: Wild ungulate populations (especially deer and wild boar) have in recent decades increased exponentially in numerous regions of the Northern Hemisphere, including France. They have become locally overabundant, with increasing number of studies reporting severe impacts on forest dynamics and biodiversity. High browsing pressures have led to biotic impoverishment and homogenization of forest understory plant communities, and forest managers face increasing difficulties in regenerating the forest. Consequently, local conflicts are common among foresters, farmers, hunters and nature conservationists that prioritize different management objectives. Adaptive wildlife management is seen as a way of improving the management of wild ungulate populations and their impact on socio-ecosystems. First, we present some French case studies of adaptive management, and discuss their successes and failures in trying to reconcile forest production and hunting. Next, we present some preliminary results from a new research project on adaptive management of forest production and hunting, where environmental risk assessment and management are tested as a tool for managing the impacts of wild ungulates on forest regeneration. Finally, we conclude by giving some perspectives related to the implementation of the new legislative framework on forest management in France.

large herbivore, tree, integrated management

K 1 (Konzerthaus Freiburg)

IUFRO17-1248 **Gap creation in post-coppice woodlands may increase both resilience and resistance of plant species against ungulate herbivory: an analysis based on life-history strategy theories**

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(1) The University of Tokyo, Kashiwa, Japan; (2) The University of Tokyo, Tanashi Forest, Nishi-Tokyo, Japan

Abstract: Impact of overabundant deer on forest vegetation is a serious concern in many developed countries. Increasing resilience, as well as resistance, of the vegetation is an upcoming interest of forest managers, as some of the damaged forests do not recover even after deer is excluded.
Our achievements from a 10-years outdoor experiment will show biological homogenization in abandoned woodlands magnify vegetation damage by herbivory. Plant functional traits (e.g. contents of defensive chemicals, growth rate and photosynthetic character) were quite different between experimental plots with gaps or canopies and those with and without herbivory. These results, together with the life-history strategy of plant defense, show us how overshading can reduce resilience of vegetation. Besides, these results will propose a possibility of increasing resilience and resistance of vegetation, and eventually recover the ecosystem function, through the management of upper vegetation.
Our results could be shared by people who are going to consider deer impact from the ecosystem point of view. This viewpoint would be essential in future, as deer overabundance and abandonment of woodlands have originated from a same issue of forest underuse, though not have been given a priority.

Biological homogenization, Deer, Defense strategy

K 1 (Konzerthaus Freiburg)

IUFRO17-234 **Wild ungulate management for natural regeneration in Los Alcornocales Natural Park**

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Abstract: Los Alcornocales Natural Park is located in southern Europe, in the region of Andalusia between the Atlantic Ocean and the Mediterranean Sea, forming one of the most extensive cork oak forests in the world. However, this territory is threatened, mainly due to the aging and decay of the forests and the almost total absence of natural regeneration, caused by excessive pressure from wild ungulates.
This paper presents the key in the historic management, which led these forests to this situation and the measures taken by the Andalusian government in recent years to reverse the situation, and a first analysis of the results obtained to date. These measures are mainly based on the establishment of large exclusion enclosures, creating regeneration areas free of herbivory, and the application of a specific management plan for wild ungulates around the Natural Area.

ungulates, regeneration, enclosures,

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

16 - Joint management of large herbivores and forests for resilient ecosystems

K 1 (Konzerthaus Freiburg)

IUFRO17-133 **Native ungulates and ecosystem functioning: an integrated approach**

Baltzinger, C.* (1)

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Abstract: Successive ecological filtering processes including dispersal limitation, environmental filtering and biotic interactions among plants and across trophic levels act upon regional species pools to form dynamic transient plant assemblages. Native herbivorous ungulates regularly disperse numerous seeds, create local chemical and physical heterogeneity through small scale soil disturbance and also selectively consume plants, whereby they shape plant assemblages by intervening in the different ecological filtering processes. The ecological processes through which large ungulates locally affect both abiotic and biotic conditions make plant communities more susceptible to invasion by non-resident species; we therefore discuss ungulates' role in shaping plant assemblages within the framework of the theory of invasibility (Davis et al., 2000). We specifically highlight how complementary zoochorous processes in a guild of large ungulates affect the composition and spatial distribution patterns of plant assemblages. First, we use a trait-based meta-analysis to show how endozoochory, hoof- and hair-epizoochory differentially filter the regional species pool. Then, we show how interactions among vectors, seeds and plant traits intervene in the seed dispersal cycle. Finally, we highlight how closely ungulates may combine seed dispersal with abiotic filtering.
We show that herbivorous ungulates, as selective and daily long-distance seed dispersal vectors, play a role in determining the spatial and temporal dynamics of meta-communities.
As primary consumers they also occupy an in-between position within the food web and may thus compete for feeding resources with other groups such as insects with potential trophic cascading effects on bird communities.
Through the many interactions ungulates are involved in, we have to consider their global role as dynamic actors in ecosystem functioning and potential tools to rehabilitate degraded habitats via seed dispersal.

herbivory, zoochory, engineering effects, filter

K 1 (Konzerthaus Freiburg)

IUFRO17-2065 **From deer versus forests to deer and forests: an adaptive management case study from the U.S.A.**

Rooney, T.* (1)

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Abstract: Adaptive management is a framework for improving sustainable management of natural resources by learning from management interventions. This framework is particularly useful for managing complex social-ecological systems. This case study examines an application of adaptive management of a deer population and forest regeneration on a private property. Property owners valued large numbers of deer on the property. However, high deer populations constrained silvicultural options, and reforestation efforts regularly failed. Rather than apply a traditional management intervention to reduce deer numbers or increase regeneration, management efforts were directed at the broader social-ecological system. In addition to deer population and vegetation monitoring, non-scientific knowledge and belief systems were integrated into a broad set of sustainable management goals. Stakeholders were both engaged and mentored. One unexpected result occurred the property owners grew more interested in achieving a broader set of sustainable management outcomes. Considerations of governance, power, and property owner beliefs contributed to outcomes for both wildlife and forests.

adaptive management, deer, natural regeneration

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

109 - Promoting forest biodiversity through structural complexity? New advances in the assessment and

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3674 **Assessing the relative importance of vegetation structure for forest biodiversity: new insights from LiDAR remote sensing for conservation**

Bollmann, K.* (1); Zellweger, F. (2)

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Abstract: Climate, topography and vegetation structure are important predictors for forest biodiversity. However, the relative importance of environmental correlates of species richness varies between taxa and with scale. Apart from large scale effects of climate and topography, there is increasing evidence that vegetation structure strongly influences forest species richness and abundance at the stand scale. However, area-wide information about vegetation structure has so far limited the development of range-wide species distribution models. In this talk, we present results of studies in which we used LiDAR remote sensing to derive fine-scaled parameters of vegetation structure to investigate their relative importance (1) for predicting species richness of plants, butterflies and birds at the forest landscape scale (i.e. Switzerland), (2) to compare the performance of field- and LiDAR-based species distribution models for two forest grouse species at the forest scale (i.e. 1 km ^{2}), and (3) to assess the relationships between forest stand structure and guild-specific activity patterns of bats. We discuss the relative importance, complementarity and contribution of LiDAR-derived parameters of 3D vegetation structure for predicting species richness in forests. We finally conclude that the increasing availability of LiDAR data will support the area-wide, indirect assessment of species richness in the future and trigger the effective allocation of conservation resources according to regional priorities.

biodiversity conservation forest structure LiDAR

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1455 **Faunistic Indicators for structural diversity in temperate forests: a systematic niche-based approach**

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(1) Forest Research Institute Baden-Württemberg, Freiburg, Germany

Abstract: Given the accelerating decline of biodiversity paralleled by limited resources, methods for systematically prioritizing conservation efforts are unavoidable. Surrogate species have thus been proposed in a variety of conceptual approaches, but these often suffer from methodological issues such as solely expert-based selection procedures. We used an objective niche-based selection algorithm to identify a set of faunal focal species representing forest structural diversity in temperate forests, using Baden-W ürttemberg as example region. Based on a coarse categorization of species' resource requirements we identified species sets that covered all predefined forest structures and types with the most sensitive species at different spatial scales. We examined the effect of variance in expert scoring on the stability of set composition. Candidate species were defined for mammals (N=24), birds (27), amphibians & reptiles (17), lepidoptera (36) and saproxylic beetles (37). The resulting sets consisted of six (amphibians and reptiles) up to thirteen (lepidoptera) species. Differences in expert scoring had a major effect on set composition, but dissimilarity between sets decreased with an increasing number of included experts. Niche-based selection algorithms proved valuable for systematically selecting surrogate species for promoting structural complexity in forest ecosystems as they require a clear definition of the conservation-targets to be covered.

surrogate species, systematic selection

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3264 **The conservation of forest structural complexity through retention forestry: a bird's perspective.**

Basile, M.* (1); Mikusinski, G. (2); Storch, I. (1)

(1) Chair of Wildlife Ecology and Management, Univ. of Freiburg, Freiburg, Germany; (2) Department of Ecology, SLU, Grimsö, Sweden

Abstract: Retention forestry is a management practice, which implies the conservation of forest's structural and compositional complexity. Retention forestry is gaining attention in recent years due to the benefits it apparently provides to biodiversity, without causing big loss in wood biomass harvest. Different levels of wood biomass may be retained during the harvest causing different levels of spatial and structural complexity. Currently, several reviews have assessed whether retention forestry, in contrast with more intensive management practices (e.g. clearcutting), was beneficial for biodiversity, but they failed in pointing out a clear effect and concluded that identification of thresholds for retention amounts to achieve desired outcomes is the main research challenge. In this meta-analysis, we aim at quantifying the effects of retention forestry on biodiversity along two gradients of structural complexity: the within-stand complexity and the between-stand complexity. We focused on birds, which have been often proposed as bio-indicators for forest management intensity and are among the most studied forest taxa. We considered only studies that reported information on bird species richness or abundance in relation to the amount of retention applied. Search in WebOfScience and Google Scholar resulted in 24 studies and 100 data points. We implemented a meta-regression to assess the effect of the amount of retention on bird species richness and abundance. We found an overall positive effect of retention amount on species abundance and richness. However, many factors play an important role, such as specific life history traits or the silvicultural system. We stress that the retention forestry is mostly applied over clear-cut. The results are discussed in the context of the European and North American forest management systems. This study was carried out within the framework of the ConFoBi Research Training Group at Freiburg University.

specialist, cavity nester, meta-analysis, ConFoBi

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

109 - Promoting forest biodiversity through structural complexity? New advances in the assessment and

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3776 **Deadwood accumulation in beech forest triggers community homogenization in formerly different management intensities**

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Abstract: Deadwood is a resource which has drastically been altered in its amount in forests over the last centuries due to the increase of human forest use. Historical minimum of deadwood amount has been reached around 1750 in central Europe, and awareness for its importance was nearly absent until 1989. In the mid 2000 a forest company started a program favoring accumulation of deadwood in managed forests. Here we compared before and after monitoring data in three historically distinct forest types, unmanaged, conservation oriented managed and economically optimized beech forests to assess if this strategy is effective in promoting saproxylic beetles. The first sampling was in 2004 before dead wood accumulation started, and the second ten years later. Results show that differences in species richness and community composition found between the forest types in 2004 were stronger than in 2014. Historically most intensively managed forest parts became similar to the unmanaged sites in terms of species richness and community composition. We conclude that deadwood accumulation is a valuable conservation method for saproxylic beetles especially in intensively managed forest, in order to even out differences between managed forest parts and surrounding unmanaged forest parts.

saproxylic, beetles, conservation

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3703 **Forest management cessation and biodiversity: a synthesis of a nationwide French project**

Gosselin, F.* (1); Paillet, Y. (1); Gosselin, M. (1); Larrieu, L. (2); Marell, A. (1); Boulanger, V. (3); Debaive, N. (4); Archaux, F. (1); Bouget, C. (1); Gilg, O. (4); Rocquencourt, A. (1); Drapier, N. (5)

(1) Irstea, EFNO, Nogent-sur-Vernisson, France; (2) INRA, UMR Dynafor, Castanet Tolosan Cedex, France; (3) ONF, Fontainebleau, France; (4) RNF, DIJON, France; (5) ONF, Paris, France

Abstract: Extending the network of strict forest reserves is one of the conservation measures promoted by the French National Strategy for Biodiversity improvement. According to the scientific literature, strict forest reserves may help preserving a part of the biodiversity that is threatened by forestry. However, this strategy is based on poor knowledge in the temperate context and available studies may suffer from methodological shortcomings.
The national-scale project named "Forest management, Naturalness and Biodiversity" aims at quantifying the effects on forest structure and biodiversity of management abandonment in strict reserves.
Based on a meta-analysis of worldwide literature and original data from 213 study plots set up in 15 forest sites throughout France - around half of the plots in forests left unmanaged for from 8 to 148 years (mean: 46 years)- , we analyzed the response of 7 taxonomic groups to management abandonment. The meta-analysis demonstrates that forestry affects total richness of saproxylic taxa worldwide, which is verified in our national dataset. However, management abandonment per se is not always the best explanation of the differences between managed and unmanaged forests, but other variables, notably linked to deadwood, better explain the observed patterns for saproxylic groups. For other taxa, the response is weaker and depends more on structural features than on management abandonment.
In terms of policy, our project has allowed methodological advances thanks to the development of inventory and remote sensing protocols, as well as statistical methods. The dataset we have gathered is also a first comparison of structure and biodiversity between strict forest reserves and managed forests for France. This network may therefore constitute a first basis for long term biodiversity monitoring in French forests.

Forest biodiversity; Stand structure; naturalness

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3227 **Please do not disturb - A chance is needed in the way forests are treated after natural disturbances**

Thorn, S.* (1)

(1) Field Station Fabrikschleichach, University of Würzburg, Rauhenebrach, Germany

Abstract: Logging to salvage economic returns of forests affected by natural disturbances continues to generate public debates. This controversy has been caused by the negative impacts of salvage logging to different aspects of biodiversity and ecosystem functioning in naturally disturbed forests. This talks gives a brief overview of these impacts and highlights nine broad impact categories including the loss of biological legacies, disruption of in-situ population recovery as well as elevated risk of ecosystem collapse. Furthermore, the results of a meta-analysis underline the need to retain significant amounts of dead wood in salvage logging to maintain the biodiversity of saproxylic groups. The talk highlights strategies for best managing naturally disturbed forests in the future and reports existing gaps in scientific knowledge. Last, a novel approach for estimating suitable area sizes of disturbed forests to be set-aside in salvage logged areas is presented.

salvage logging, meta-analysis

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

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Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1775 **Forest biodiversity in numbers - The German National Forest Inventory as a basis for forest biodiversity monitoring**

Winter, S.* (1); Reise, J. (1); Kukulka, F. (1); Trotzer, S. (2); Wenz, E. (1); Linde, A. (1)

(1) University for Sustainable Development Eberswalde, Faculty for Forest and Environment, Eberswalde, Germany; (2) Universität Potsdam, Potsdam, Germany

Abstract: The sustainable usage of wood is an important topic of the German National Strategy on Biodiversity. Enforcing the strategy must be accompanied by a continuous monitoring to document the development of forest structures relevant to biodiversity. The national forest inventory (NFI) is conducted every 10 years and records more than 150 structural characteristics on 58.844 sample points. Although there is no monitoring of typical forest species, there are nationwide species distribution maps of forest birds, bats, bryophytes and vascular plants in Germany. We merged these species distribution data with the NFI data and used Random Forest models to analyse the relation. Results indicate that the percentage of main tree species of the natural forest communities, historical forests and forest ownerships are NFI variables of importance for forest species. Highest model accuracies were achieved when ecological drivers of biodiversity distribution like the biogeographic region were integrated into the model. This study shows that some variables recorded by the NFI can support a future forest biodiversity monitoring scheme. We suggest synchronizing national species monitoring efforts with the NFI in terms of time and sampling plot pattern to increase chances to identify structural patterns which determine changes in forest species richness and diversity.

National forest inventory, monitoring biodiversity

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3994 **Multi-scale biodiversity monitoring in the Black Forest National Park**

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(1) Black Forest National Park, Ecological Monitoring, Research & Conservation , Freudenstadt, Germany

Abstract: The Black Forest National Park was founded in 2014 as a strictly protected forest area. It provides us with an opportunity to monitor the development of a recent commercial forest into a secondary wilderness.
There is only a short window of opportunity to benchmark the biodiversity as well as habitat and abiotic protection functions of the forest landscape. Our approach is multi-scale and multi-organismic.

Our landscape scale approach has been to use different remote sensing data to map habitat structures and model the successional stages. This analysis has been combined with a detailed terrestrial assessment. The distribution of our 245 monitoring plots was based on a stratification of topographic, climatic and soil development features juxtaposed on the state forest administration's permanent sampling grid. At the plot level the forest structure and different organism groups (plants, bryophytes, lichens and fungi as well as vertebrates and invertebrates) are assessed within a nested plot design. This design allows us to analyze structural change and its influence on the interactions of different functional ecosystem groups. Our intent, with this approach, is to facilitate cooperation and enable the comparison our data with that of other strictly protected forest reserves within Germany and internationally.

forest dynamic, structure assessment

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2555 **Evaluation and Monitoring of a concept to protect habitat trees and deadwood**

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Abstract: Deadwood and a high density of microhabitats in forest ecosystems are essential for ecosystem diversity. To enlarge the amount of deadwood and microhabitat-bearing trees within managed forests, the German state Baden-W ürttemberg designed a so-called "habitat-tree-and-deadwood" management concept as integrative biodiversity conservation instrument. Groups of habitat trees (mainly old (>200years) and already microhabitat-bearing trees) and small areas of one to three ha are selected and conserved within this concept.
For the first systematic evaluation of this concept, the indicators of tree age, microhabitat rarity, threatened species, deadwood, and connectivity were selected and analyzed. The analysis has already revealed that the total amount of dead wood volume within the groups of habitat trees is twice as high as the average in Baden-W ürttemberg forests. One main objective of the concept was to enhance the forest matrix outside strictly protected areas with relevant microhabitats. Already it can be shown that the mean closest distance to the next unmanaged area decreased when this concept was implemented.
In addition to the evaluation results, we compare these areas to reference areas.
Further a first approach for a long-term monitoring of the "habitat-tree-and-deadwood" management concept will be presented.

microhabitats, integration, connectivity

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

45 - Forest policy and biodiversity strategy: The relevance of forest genetic resources

KG I - 1015 (Uni Freiburg)

IUFRO17-2224 **Pan-European efforts in biodiversity conservation**

Skoberne, P.* (1)

(1) Ministrstvo za okolje in prostor, Ljubljana, Slovenia

Abstract: Long-term aimed management of forests is usually very close to nature conservation goals. Even some early beginnings of nature conservation activities in Europe are connected with 'reservations' of landowners. In 70's of the 20th century it became obvious that only internationalisation of nature conservation concerns can be efficient as nature does not respect political borders. It started with the Bern Convention, followed by many initiatives. Important mile stone was adoption of the Convention on Biological Diversity (1992), confirming at the highest global political level that Earth resources are limited and has to be used sustainably. Among many responses to those commitments for forest conservation on Pan-European level the most relevant is the ministerial processes Forest Europe and on EU level EU Biodiversity Strategy. Nature conservation developed from single-species protection to habitat protection and ecological network concept (Natura 2000, Emerald). Efforts are made on all 3 levels of biodiversity: genetic, species and ecosystem level. The main challenge remains to efficiently streamline all activities and to revert economic paradigm of unlimited growth to sustainable concept.
We learned from nature that richness of biodiversity means stability though adaptability. We have a wide diversity of initiatives and actions from global to local level. Now we have to learn next lesson from nature: how all these solitaire trees can function as a forest!

forest, biodiversity, nature conservation

KG I - 1015 (Uni Freiburg)

IUFRO17-2395 **The importance of genetic diversity for sustainable forestry**

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(1) INRA, URFM, Avignon, France; (2) Bioversity, Maccarese , Italy

Abstract: In the context of the challenges posed by climate change and continuously evolving demands for forest products and services, the European forestry sector needs to operate on the basis of enhanced knowledge, methods and tools for the management and sustainable use of forest genetic resources (FGR). FGR significantly contribute to maintaining genetic diversity and adaptive potential in European tree species. In situ and ex situ conservation efforts in favor of FGR need to be improved through a better characterization of the adaptive potential of what is being conserved and the identification of major existing gaps. Scientific advances are needed to better describe phenotypic and genotypic diversity of important tree species, and examine at which spatial scale and in which habitats adaptive responses are taking place.

In addition, research needs to expand and include underused European forest tree species. Breeding programs should encompass new species and new source populations. It also needs to consider innovative methods for improving and deploying forest reproductive material able to withstand pressures from climate change and meet new emerging demands. The next generation of forest management scenarios and policy frameworks will need to fully integrate genetic conservation and breeding aspects. Examples of how these objectives are being addressed within the H2020 GenTree project (http://gentree-h2020.eu/) will be provided.

Genetics adaptation climate conservation breeding

KG I - 1015 (Uni Freiburg)

IUFRO17-3544 **Selection of best management practices for conservation of spatial genetic structure diversity and dynamics in beech forests**

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Abstract: The Italian forests are the result of a millenary coevolution between ecological and socio-economic reality, changing appreciably the biodiversity of forests with a reduction of their complexity. Thus, it is important to examine the best management practices for forest genetic resources conservation to preserve adaptability of forest ecosystems.
We evaluated the effects of silvicultural systems on the genetic diversity in two beech high forest stands in the Apennines (central Italy). We did a comparison between an even-aged stand managed by the uniform shelterwood system (Nature Reserve) and a uneven-aged stand managed with a type of single tree selection felling carried out according to traditional knowledge (Baldo's Forest). All trees were genotyped using nSSR loci. General estimates of genetic diversity in the stands were calculated using SPAGeDi 1.5a. The spatial genetic structure of the stands was analyzed by STRUCTURE program and Geneland software.
The two stands showed no significant differences in genetic diversity measures, while significant differences were detected on the number of rare alleles and on the spatial structure of genetic diversity. The stand of Nature Reserve presents a structure of random type, devoid of family groups, characterized by gene flows limited in space and with low recombination rates. In contrast, the stand of Baldo's Forest presents a spatial structure of genetic diversity grouped into families, with wide dispersion gene rates, high rates of recombination and a greater number of rare alleles. The spatial genetic structure diversity found in the uneven-aged Baldo's forest was similar to that observed in previous studies carried out in old-growth beech forests in the Apennines. The single tree selection felling, which is repeated at short intervals of time (every 5-6 years), seems to lead to a faster fragmentation of family groups, thus speeding up the evolutionary dynamics of the managed stand compared to the old-growth forest.

Genetic diversity, SGS, forest management

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45 - Forest policy and biodiversity strategy: The relevance of forest genetic resources

KG I - 1015 (Uni Freiburg)

IUFRO17-1320 **The days of the Serbian spruce in its natural habitat are numbered**

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Abstract: Conservation programs, aimed at providing the long-term persistence of forest genetic resources, are commonly formulated depending on the standing neutral genetic variation and/or adaptive potential of forest tree species and their populations. However, in terms of the accelerating climate change, genetic variation may be lost rapidly, and forest adaptability may simply be insufficient to keep up with the rate of climate changes. Thus, implementation of forest genetic resources monitoring into conservation programs is nowadays necessary. This is particularly important for currently the most threatened populations (marginal populations) and species (those with a limited natural range). Serbian spruce [Picea omorika (Panc.) Purk.] is a rare conifer endemic to the Balkans. The total number of remnant populations is c. 30. They are scattered within an area of c. 100 km2 and comprised of several hundreds to several thousands of trees. This intriguing species is legally protected by the law since 1950, and it has been IUCN red-listed in 1998(categoryendangered). I will present recent results on Serbian spruce neutral genetic diversity and genetic structure, and discuss the prospects of current conservation measures to enable species long-term survival. Unless continuous monitoring and alternative conservation measures are implemented in the near future, Serbian spruce will disappear from its natural habitats in forthcoming decades.

Picea omorika, monitoring, conservation

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IUFRO17-3644 **LocalyTREE - DNA-based analytics to characterise 'genetic' regions of Lower Austria aiming to support the selection and plantation of native shrub species**

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Abstract: All over the world, re-plantation is widely used to reverse environmental degradation caused mainly by human activities. A critical question in this context involves the origin of genetic material to be used in order to preserve the original native setting of the ecosystem as well as its fitness. This question even becomes more important, since due to an amendment of the nature conservation law, only regional, native shrubs are allowed to be planted on public land, as is the case in Lower Austria from 2022 onwards. Per definitionem, native plants are plants indigenous to a given area that have developed, or existed for many years in that area, and have been adapted to the local environmental conditions. But, where to set the geographical boundaries for the population range of a native plant community, and on what background? How fine must a region be structured to correctly represent the genetic integrity of a population? Thus, the clarification of the population structure to infer its regional origin is an essential part for the implementation of the law amendment.
In the current study, we investigated the population structure of five shrub species assigned to different pollination systems: Cornus mas (bee-pollinated), Prunus spinosa (bee-pollinated), Sambucus nigra (fly- and bug-pollinated), Frangula alnus (insect- and self-pollinated), and Acer campestre (wind-pollinated). Of each species 80 individuals were collected randomly all over Lower Austria (19.000 km ²). To infer population genetic structure by molecular genetic tools, at least 10 microsatellite markers were analysed per species. The so gained knowledge about the species-specific pattern of genetic diversity served us for the creation of a 'genetic' map. Together with the geographical and ecological regions of Lower Austria, the herein identified 'genetic' regions provide guidance in the determination of the regional origin aiming to support the selection and plantation of native shrub species.

genetic diversity, regional origin, native species

KG I - 1015 (Uni Freiburg)

IUFRO17-3378 **Regional Cooperation for Genetic Diversity Conservation of Pinus pumila in East Asia**

Kang, H. S.* (1); Kim, I. S. (2); Bang, M. (1); Kwon, H. J. (2); Lee, C. H. (2); Park, J. H. (1); Cheng, H. C. (1)

(1) Seoul National University, Seoul, Korea, Republic of (South Korea); (2) Korea National Arboretum,, Pocheon, Korea, Republic of (South Korea)

Abstract: *Pinus pumila* is an endemic plant in East Asia, distributed in Russia (Eastern Siberia, Far East excluding Chukota), Mongolia (Khentii), Republic of Korea (northeast part), China (northeastern part) and Japan (Honshu and Hokkaido). *P. pumila* is one of the species that have extensive geographic ranges, and its population is thought to be stable and has been assessed as being of little concern in its major area such as Eastern Siberia and northeastern China. Nevertheless, *P. pumila* is vulnerable at the southernmost limit of its range in response to global warming, which is on Mt. Seorak in the Republic of Korea, and it has been categorized as critically endangered species and one of the target species for strategic genetic resources conservation in the Republic of Korea. In this context, initiated by Korea National Arboretum, the member institutions of the East Asia Biodiversity Conservation Network (which consists of the countries of Russia, China, Mongolia, Japan, Republic of Korea) have conducted collaborative research on DNA comparative analysis of the leaf samples of *P. pumila* each country to establish effective strategies for genetic diversity conservation of *P. pumila* in the regional level.

genetic, biodiversity conservation, Pinus pumila

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

45 - Forest policy and biodiversity strategy: The relevance of forest genetic resources

KG I - 1015 (Uni Freiburg)

IUFRO17-1749 **Conservation and management of forest genetic resources: overview on forest policies in countries of South Eastern Europe (SEE)**

Stojnic, S.* (1); Stevanov, M. (1); Alizoti, P. (2); Andonovski, V. (3); Avramidou, E. (2); Ballian, D. (4); Bozic, G. (5); Ivankovic, M. (6); Georgiadou, M. (7); Hasilidis, P. (7); Orlovic, S. (1); Stijovic, A. (8); Toromani, E. (9); Westergren, M. (5); Kraigher, H. (5)

(1) Institute of Lowland Forestry and Environment, Novi Sad, Serbia; (2) Aristotle University of Thessaloniki, Thessaloniki, Greece; (3) University Ss. Cyril and Methodius, Faculty of Forestry, Skopje, Macedonia, the former Yugoslav Republic of; (4) University of Sarajevo, Faculty of Forestry, Sarajevo, Bosnia and Herzegovina; (5) Slovenian Forestry Institute, Ljubljana, Slovenia; (6) Croatian Forest Research Institute, Jastrebarsko, Croatia; (7) General Directorate for Forests and Rural Affairs, Thessaloniki, Greece; (8) Institute of Forestry, Podgorica, Montenegro; (9) Agricultural University of Tirana, Tirana, Albania

Abstract: Forest genetic resources (FGR) are essential part of the adaptation and evolutionary processes of forest ecosystems. Therefore, the conservation and appropriate use of FGR are of importance for sustainable forest management. Several European policies, such as FOREST EUROPE, Convention on Biological Diversity (CBD), EU Forest Strategy and Rural Development Programme (RDP) have recognized the importance of FGR and have specifically mentioned it. Furthermore, Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources (GPA-FGR) was adopted by FAO in 2013 in order to support the implementation of CBD commitments, and to strengthen the conservation and use of FGR as part of sustainable forest management. In 2013, A new EU Forest Strategy: for forests and the forest-based sector (COM(2013)659) was also developed to provide a framework for the forest sector itself and related policies, such as climate change, bioenergy, biodiversity, bio-based economy, rural development, etc. Additionally, European Union (EU) policies on invasive alien species (Regulation 1143/2014) and protective measures against the introduction and spreading of organisms harmful to plants health (Council Directive 2000/29/EC) may also have an influence on FGR by minimizing the genetic erosion that might be potentially caused by these threats. In line with that, specific countries adopted diverse strategies that best suit their particular conservation and management needs and interests. In the present research we put the focus on a comprehensive overview of forest policies in selected South-East European (SEE) countries, with respect to conservation and use of FGR. Provided overview of national approaches and documents is expected to highlight the most important points, comparison of which might be suitable contribution to regional policy discussions on the future of sustainable forestry in SEE region.

FGR, forest policy, South-East Europe

KG I - 1015 (Uni Freiburg)

IUFRO17-661 **Forest genetic monitoring: an overview of concepts and definitions**

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Abstract: Safeguarding sustainability of forest ecosystems with their habitat variability and all their functions is of highest priority. Therefore, the long-term adaptability of forest ecosystems to a changing environment must be secured, e.g., through sustainable forest management. High adaptability is based on biological variation starting at the genetic level. Thus, the ultimate goal of the Convention on Biological Diversity (CBD) to halt the ongoing erosion of biological variation is of utmost importance for forest ecosystem functioning and sustainability. Monitoring of biological diversity over time is needed to detect changes that threaten these biological resources. Genetic variation, as an integral part of biological diversity, needs special attention, and its monitoring can ensure its effective conservation.We compare forest genetic monitoring to other biodiversity monitoring concepts. Forest genetic monitoring (FGM) enables early detection of potentially harmful changes of forest adaptability before these appear at higher biodiversity levels (e.g., species or ecosystem diversity) and can improve the sustainability of applied forest management practices and direct further research. Theoretical genetic monitoring concepts developed up to now need to be evaluated before being implemented on a national and international scale. This article provides an overview of FGM concepts and definitions, discusses their advantages and disadvantages, and provides a flow chart of the steps needed for the optimization and implementation of FGM. FGM is an important module of biodiversity monitoring, and we define an effective FGM scheme as consisting of an assessment of a forest population's capacity to survive, reproduce, and persist under rapid environmental changes on a long-term scale.

Indicators, Verifiers, Genetic diversity, FGM

KG I - 1015 (Uni Freiburg)

IUFRO17-2465 **Monitoring flowering synchronization discrepancies and their impact on seed crop genetic diversity - An early warning system in a changing climate**

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Abstract: Flowering phenology in forest trees is a decisive factor affecting gene exchange among genotypes and seed crop genetic diversity, while its initiation and duration is drastically affected by environmental factors. Climate change, by increasing the frequency and duration of xerothermic cues, may lead to biodiversity loss, as affecting physiology, phenology and species persistence. Flowering phenology and synchronization of sixty genotypes was monitored for two successive and climatically contrasting years, in a black pine seed orchard. The results showed a high synchronization discrepancy during the xerothermic year, as male flowering ended almost before female flowering reached the full receptive stage. The mating pattern of twenty maternal genotypes (producing seed in both years) was recorded by performing paternity analysis on sixteen seeds per mother tree, based on six polymorphic nuclear SSRs. The progeny types produced in the xerothermic year versus the normal year, consisted of 25% less selfs, 65% more full sibs, 10% more half sibs fathered by clones of the seed orchard and 50% less half sibs fathered by alien pollen. Mating during the xerothermic year was mainly among closely located genotypes. The climate change impact on the genetic diversity of seed crop and the significance of monitoring will be discussed.

asynchrony, clonal seed orchard, diversity loss

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

45 - Forest policy and biodiversity strategy: The relevance of forest genetic resources

KG I - 1015 (Uni Freiburg)

IUFRO17-1992 **Communicating the value of forest related nature's services and genetic resources today for tomorrow**

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Abstract: To ensure appreciation of forest related nature's services, they must be presented to the public in an appropriate way. Humans are usually not willing to pay for something they consider as 'free goods' (Coull and Valantin, 2008). The challenge is changing the mind-set through awareness-raising. A good communication strategy should convey the message as a tangible concern that contributes to the quality of our lives (IUCN). Communicating nature's services will help understand the benefits we gain and joy and pleasure they can give us if we treat them with knowledge, respect and wisdom (Wiborn, 2013).
The actions taken in the past are not giving the results we need. Hohnen (2001) suggests that a multi-stakeholder approach can harness the creativity from stakeholders through solution driven dialogue.
In the LIFEGENMON project , coordinated by Slovenian Forestry Institute, the multi-stakeholder approach is used to communicate the forest related nature's services and importance of genetic resources. A clear visual and verbal communication brings the key project messages to life. To forge meaningful connections with core stakeholders it is essential to use compelling and targeted messages. Ultimately, the results will demonstrate the value of engaging supporters in co-creating communications to extend reach and impact.

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value of FGM, communicating, multi-stakeholder

KG I - 1015 (Uni Freiburg)

IUFRO17-1711 **The future of forest genetic monitoring (FGM): a contribution to FGM objectives and strategies from local to global**

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Abstract: The manifestation of significant environmental change calls for scaling up forest genetic monitoring (FGM) approaches for securing tree species survival and adaptive potential. Genetic monitoring, the quantification of temporal changes in population genetic variation and structure, elucidates processes that maintain genetic variation in natural populations, introduces prognosis and helps define tools for forest gene conservation, policy and management. The future transition to genomic monitoring is expected to increase precision in estimates of population genetic diversity and adaptive genetic potential and provide an enhanced potential for disentangling natural selection from demography, and the influence of environmental gradients on genetic variation. Further future FGM objectives may include: an epigenetic/epigenomic component, as epigenetic variation appears to influence many phenotypic traits involved in local adaptation, and a metagenomic component offering insights in the co-evolutionary interactions across above/below ground forest communities. FGM will be more limited by time-consuming procedures in the assessment of demography and by conceptual weaknesses in biostatistical tools for analysing genomic and epigenomic data, than by genotyping needs and the amount/cost of available sequence data. In the strategic front from the local to the global scale, FGM should secure long-term funding that would provide at least a basic level of assessment.

genetic monitoring, gene conservation, policy

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

2 - Co-existence of human and wildlife in changing landscapes and climate

K 1 (Konzerthaus Freiburg)

IUFRO17-1601 **Roles of non-protected areas for habitat of endangered Proboscis Monkey (Nasalis larvatus) under current land-use policy in West Kalimantan Province, Indonesia**

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Abstract: Proboscis monkey is an endemic species to the island of Borneo with the conservation status IUCN of endangered. The population size of the monkey progressively decreased due to the continued decline in the number of their habitat through forest degradation and conversion. The population of monkey in 2008 was estimated that only approximately 25.000 individuals and only 5.000 individuals in conservation areas. However, continue habitat degradation is hardly prevented in non-protected areas. Since the conservation of an endangered species needs further attention at local distribution, the absence of the spatial distribution data of proboscis monkey systematically across locations led to the need for research on the prediction distribution of the monkeys. This study aims to build predictive models of the monkeys on Borneo island. The study used the Species Distribution Modelling (SDM) approach with Maxent software. We collected presence data and used various environmental data such as topography, vegetation index and distance from roads and village to generate predictive distribution maps of monkeys. The species distribution model was overlaid with the current land-use change in West Kalimantan Province, to calculate gap size between protected areas and non-protected areas and provide scientific guidance for the future development incorporating biodiversity issue.

Proboscis monkey, spasial distribution, maxent

K 1 (Konzerthaus Freiburg)

IUFRO17-3997 **Religious and ethnological forces shaping perceptions and conservation of warthog in Benin**

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Abstract: Wildlife is one of the products that interconnects people with forests. This biodiversity component plays differents roles to population as well as has several useful ecosystem services. Amongst its importance, one has the use as food and animal-based medecine stuffs.
Warthog is one of Benin fauna that is only found in protected areas and which meat and other parts are used by surrounding population of those protected areas. Currently, the population dynamic of this species is thought to be negatively impacted. Therefore, we assessed perception and knowledge of local inhabitants of a protected area in Northern Benin to better understand challenges to warthog conservation and management. This was linked to religious precept and ethnological aspects. Face-to-face interviews of randomly selected inhabitants, adopting a cross sectional mixed research design and structured and semi-structured questionnaires was carried out from June to December 2016. As results, the species is largelly known locally but religious and ethnological forces shaping its perception, use and conservation. These results are importants and could be considered in formulating key messages for sensibilization on how to manage and conserve wildlife in changing landscapes and then facilitate sustainable co-existence between human and wildlife.

Wildlife,Religion,ethnological impacts,perception

K 1 (Konzerthaus Freiburg)

IUFRO17-1607 **Predicted Distribution of The Sunda Pangolin (Manis javanica) on Southest Asia**

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Abstract: Pangolin (Manis javanica) is a species that has a high economy value and thus susceptible to poaching. Currently, the pangolin became one of the endangered species with conservation status critical engendered of IUCN. This is certainly a basic importance for us to know the distribution of pangolin for immediate conservation efforts to protect these animals. Information on the distribution of pangolin (Manis javanica) in all locations of Southest Asia is still very limited even no systematic information about the distribution of this species. Maximum Entropy (MaxEnt) is one way to predict the distribution of pangolin which can be done with a regional scale so that it can be a practical guide for the conservation of the species. We collected data pangolin presence in some areas of Southeast Asia and conduct collaborative research by requesting data from several researchers pangolin in Southeast Asia. We use a literature study, field study and use of environmental data. This study uses a distribution model with quantitative methods. This model uses a statistical analysis of Generalized Linear Model with logistic regression were implemented into MaxEnt. Based on the predictions of this distribution, we hope to draw up priority areas for conservation of pangolins in Indonesia.

Pangolin, Distribution, the MaxEnt, conservation

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

2 - Co-existence of human and wildlife in changing landscapes and climate

K 1 (Konzerthaus Freiburg)

IUFRO17-906 **Effectiveness of protected area in conserving the highly hinting bush meat species in Southern Benin**

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Abstract: Using the occupancy-based methods, we investigated the distribution, habitat selection of game mammals in the Lama classified forest to evaluate how different management designation, anthropogenic influences and habitat type influenced the occurrence of each species. We used a combination of track surveys in grilled-cell system and questionnaire survey with the local communities. Twenty one species have been predominantly reported by the local inhabitants to be most consumed bush meat species and 9 of them have been identified as the most hunted game mammals in the local community areas of the Lama classified forest. The selection of the preferred habitat among the swamp forest, the dense forest, the forest plantations and fallow for the prioritized game species varies between species but looks similar when grouping in different orders. This study did show us that the zoning system in the Lama classified forest can't passively protect all the species in forest as some although the secured environment of the core zone were found mostly distributed in the plantations and fallow vegetation where they are overhunted. This result implies that manager of the Lama's forest should give more caution in managing the area.

Bushmeat, zoning, preferred habitat, occurence

K 1 (Konzerthaus Freiburg)

IUFRO17-3870 **Planning the future forests: managing for wildlife in a climate constrained landscape**

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Abstract: Multipurpose functionality is a paradigm when it comes to forest management. This includes sustainability, resilience, stand stability, wildlife management, recreation, clean water and air, or healthy soils - to name a few. The world is aiming at a maximum global warming of 2-deg by 2100, but cumulative emissions are still rising. Higher temperatures are associated with higher risks of extreme events such as storm, flood, droughts, pests and fires etc. - and at the same time, forest systems are key for any mitigation activity to avoid such dangerous climate change. But how will a managed forest look like in the future? How can we understand the underlying dynamics and make our forests fit for the increased need for carbon storage, biomass for energy and sustainable wood and non-wood forest products like game, while maintaining biodiversity, recreational and protected areas. Moreover, we need to address all challenges on limited land and establish action from policy development all the way to their implementation within a short time frame. Based on Sweden's forests, traditionally considered a role model for successfully bridging a multitude of demands, we present a modeling approach that should serve as a planning tool for enhancing forests' risk resilience and capacity of integrating diverse demands and different ecosystem-services. Guided by the expertise of Sweden's Environmental Protection Agency, national forest and habitat shift models from SLU and KTH will be linked with global land use models and engineering tools from IIASA. Hereby, special emphasis will be put on ecosystem services from wildlife, different scenarios of forest intensification and the optimization of biomass for bioenergy production. First estimates show that spatially explicit modeling can substantially support decision making by optimizing multipurpose use of both managed and protected areas and steering habitat shift for maintaining biodiversity and improving wildlife (game) management.

wildlife,multipurpose,integrated modeling

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

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KG I - 1010 (Uni Freiburg)

IUFRO17-135 **Biological Invasions in Forests: A Global Threat**

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Abstract: Biological invasions are an unintended consequence of globalization and affect forests worldwide. Species invading forests include woody and herbaceous plants, animals such as mammals, invertebrates, protists and nematodes, as well as a variety of microorganisms such as fungi, oomycetes, bacteria and viruses. These species act in a variety of ecological roles including as primary producers, herbivores, predators, animal pathogens, plant pathogens, pollinators, decomposers, and mutualists. Most non-native species have negligible impacts on forests but a few have profound and often cascading impacts. These impacts include alteration of tree species composition, changes in forest succession, declines in biological diversity, and alteration of nutrient, carbon and water cycles. Many of these impacts result from competition with native species but also trophic influences that may result in major changes in food web structure. Naturally regenerating forests around the world have been substantially altered by invading species but planted forests also pose particular problems. Part of the exceptional growth of exotic tree species can be attributed to escape from herbivores and pathogens that exist in their native ranges. Over time, some pest species can "catch-up" with their hosts, leading to subsequent declines in forest productivity. Other impacts result when native herbivores or pathogens adapt to exotic trees or when novel associations form between pathogens and vectors. and planted non-native trees are sometimes themselves invasive. Management of invasions in forests includes prevention of arrival, eradication of nascent populations, biological control, selection for resistance in host trees and the use of cultural practices (silviculture and restoration) to minimize invader impacts. In the future, the worlds' forests are likely to be subject to increasing numbers of invasions and effective management requires greater international cooperation.

Invasive plants, herbivore, predator, decomposer

KG I - 1010 (Uni Freiburg)

IUFRO17-2607 **Biotic resistance in forest ecosystems**

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Abstract: Biotic resistance has long attracted interest in the research and management communities. However, inconsistencies exist in various biotic resistance studies. Here, we provide a brief review of the history and mechanisms of the biotic resistance hypothesis, and summarize the central topics and knowledge gaps related to biotic resistance in forest ecosystems. In addition, we synthesize ecological and statistical explanations of observed inconsistencies and provide suggestions for future research directions. Overall, biotic resistance is understudied in forests compared to other ecosystems; particularly lacking are studies on resistance to exotic pests and pathogens. Some of the observed inconsistencies on biotic resistance can be attributed to (1) the interactive or additive effects of other ecological processes and (2) the statistical artifacts of modifiable areal unit problem.

biodiversity, macroscale, statistical artifacts

KG I - 1010 (Uni Freiburg)

IUFRO17-2895 **Everything you always wanted to know about classical biological control against forest pests (but were afraid to ask)**

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Abstract: Classical biological control (CBC) is the introduction of a natural enemy of exotic origin to control a pest, usually also exotic, aiming at permanent control of the pest. CBC has been carried out widely over a variety of target organisms, but most commonly against insects, using parasitoids and predators and, occasionally, pathogens. This presentation will try to answer the questions most commonly asked regarding CBC against insect pests, with particular emphasis on tree pests. Much of the information will be based on the analysis of two databases, the BIOCAT2010 database of introductions of insect biological control agents for the CBC of insect pests, and a database of introductions of entomopathogens against insect pests. Until 2010, more than 6000 introductions of parasitoids and predators were made against 588 insect pests, leading to the control of 172 pests. About 55% of these introductions were made against pests of woody plants. Establishment rates of natural enemies and success rates were higher in CBC projects targeting pests of woody plants than other pests. The presentation will discuss rates of successes in CBC among different systems, different target insect groups and different agents; temporal trends in CBC practices and successes; economic and environmental benefits; risks and ways to mitigate the risks; CBC against native pests; accidental successes through the adoption of the invasive pests by native natural enemies or accidentally introduced agents; and prospects and constraints for the practice of CBC in the future.

classical biological control; natural enemies

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

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KG I - 1010 (Uni Freiburg)

IUFRO17-884 **Are non-native forest insects recently established in Europe spreading faster than before?**

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Abstract: Globalization is triggering an increase in the establishment of alien insects in Europe, with several species having substantial ecological and economic impacts. We investigate long-term changes in rates of species spread following establishment. We used the total area of countries invaded by 1171 insect species for which the date of first record in Europe is known, to estimate their current range radius. We estimated initial rates of radial spread and compared them among different groups of insects for all years (1800-2014) and for a subset of more recent decades (1950-2014). Decreasing spread rates over residence time were observed in herbivorous species associated with herbaceous plants and crops but much less in those related to woody plants. Initial spread rate was significantly greater for species detected after 1990, roughly 3-4 times higher than for species that arrived earlier. It is hypothesized that the political changes in Europe following the collapse of the Iron Curtain in 1989, and the further dismantling of Customs checkpoints within an enlarged European Union (EU) have facilitated the faster spread of alien insect species. Also, the number of species first recorded in the Eastern Bloc of the politically-divided Europe before 1989 was lower than for the rest of Europe. A detailed analysis of several recent invaders associated to woody plants indicated a dominant role of long-distance translocations related to human activities, especially with the plant trade, in determining rates of spread.

insect, invasion, spread, Europe, woody plants

KG I - 1010 (Uni Freiburg)

IUFRO17-3296 **Country regulations of non-native tree species in Europe**

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Abstract: Non-native tree species (NNT) play an important role in forest production in many European countries and management of NNT has a long tradition in Europe. The legal situation varies however considerably among the European countries, ranging from countries with almost no restrictions on growing NNT to countries where only very few NNT can be grown, and permission needs to be sought for every plantation. Similarly, countries have differing strategies and methods for the classification of NNT as invasive species. A standardised questionnaire on NNT regulations was sent to representatives of the 36 member countries of COST Action FP1403 'Non-native tree species for European forests: experiences, risks and opportunities' (NNEXT). We inquired if and how NNT are treated in the countries' hard laws (Forest Acts, Nature Conservation Acts) and soft laws (Guidelines, Forest certification standards, Lists of NNT of concern) and what measures have been taken so far in response to the regulation (EU) No 1143/2014 on invasive alien species. Countries could be categorised regarding their regulatory intensity. Differences in regulatory intensity across jurisdictions showed to be neither a clear predictor for NNT coverage, nor for the multitude of research activities in European countries.

Non-native trees, regulations, invasive species

KG I - 1010 (Uni Freiburg)

IUFRO17-1475 **From climate change to new diseases**

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Abstract: Sudden environmental changes may heavily impact the Earth biotas. The way climate change affects ecosystem components reducing the ability of the whole system to recover from disturbance are complex and difficult to forecast. However, the stresses associated with global change-induced disturbances will likely benefit plant pathogens both directly and indirectly, i.e. predisposing plants to infection. Abrupt alterations in weather patterns decrease ecosystem resistance to disease, and reduce ecosystem resilience facilitating the establishment of alien disease agents. It is well documented that warmer temperatures increase the risk of disease development in plants. At northern latitudes, plant growth, but also plant susceptibility to disease, are expected to increase following temperature rise. In fact, under optimal resource availability plants tend to allocate energy to growth rather than to differentiation processes, which include secondary metabolism components that have a general role in parasite defense. Non-pathogenic microbial associates, which commonly inhabit plant tissues, may shift to pathogens because environmental changes or stress factors have altered host physiology breaking the equilibrium of plant-endophyte interactions. Moreover, non-cryophilic, drought-intolerant or water-borne pathogen species, which include many fungal pathogens, may be directly favored by milder and wetter climate. Current climate change is indeed altering the distribution of organisms on Earth. In response to ongoing climate change the geographic range of many plant pests and pathogens has shifted polewards, while seasonal activities, migration patterns, species abundance of fauna and flora species, and the interactions among them, were modified. Introduction and establishment of exotic forest pests and pathogens originating from warmer regions and possibly more adapted to the changed environmental conditions is also affected.

migration, alien pathogens, cryptic pathogens

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

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KG I - 1010 (Uni Freiburg)

IUFRO17-4033 **Evaluating the invasion potential of non-native tree species in Europe**

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Abstract: For more than one century tree species from North America and from Asia have been planted in forests from the North to the South and from the West to the East of Europe. Today, their portion of the total forest area in European countries ranges between 0.2 and more then 30%. In the frame of the European COST-action NNEXT, we focus on the most abundant 15 out of roughly 200 non-native tree species and comparatively evaluate their invasion potential with respect to geography and ecosystem vulnerability. While a many publications exist on the growth and wood quality of the species, surprisingly few papers report on the regeneration success in comparison to native tree species and on the spread into natural forests. Differences between the invasion potential relate to the presence or absence of specific life history traits. For instance, most abundant conifer Douglas fir (Pseudotsuga menziesii) and broadleaf black locust (Robinia pseudoacacia) fundamentally differ in their spread and vegetative reproduction. Nonetheless, whether a species is considered invasive not only depends on proper scientific definitions and empirical evidence but also on national attitudes. By this international network we review current knowledge on the 15 focal species and present a first synthesis.

non-native trees, invasibility, traits, Europe

KG I - 1010 (Uni Freiburg)

IUFRO17-2830 **Insights into the invasiveness of eucalypts - the particular case of Eucalyptus globulus**

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Abstract: Plantations of non-native tree species have been increasing in many parts of the world. Australian eucalypts are among the most widely planted fast-growing trees on the Planet. Although they have been introduced to Europe and North America already in the early-mid 19th century, only recently with the expansion of cultivated areas there has been a marked increase of interest regarding the invasiveness of eucalypts in their introduction range. Thus, various research initiatives have aimed to get insights into the processes of seed dispersal and plant recruitment as well as on the factors that drive these processes. This paper presents unpublished results combined with recent literature, synthesizing the current scientific knowledge regarding eucalypt invasiveness, with a special focus on Eucalyptus globulus in Portugal and Spain. These two countries together hold the vast majority of eucalypt plantations in Europe. Results from independent studies show that rainfall and temperature seasonality are among the main drivers of plant recruitment (wildlings) in E. globulus plantations, at a regional scale. At the stand scale, propagule pressure, determined by stem age and stand rotation, seems to be a critical factor explaining wildling density. In addition, disturbance caused by fire is a major aspect to consider, as it triggers shedding of seed from capsules stored in the canopy. Finally, lack of management is also crucial, as wildling density is remarkably higher in abandoned plantations. Nonetheless, seed dispersal is normally restricted to the vicinity of mother trees, making the assignment of an invasive status unclear, per the most common definitions of invasiveness. This is further complicated by the fact that distinction between wildlings and planted trees is often difficult, particularly in abandoned or poorly managed plantations. The above findings are discussed, knowledge gaps are identified and future research directions are suggested.

Eucalypts, invasive, wildling establishment

KG I - 1010 (Uni Freiburg)

IUFRO17-176 **Assessment of invasiveness of introduced tree species in Europe**

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Abstract: There is an increasing awareness of potential risks of invasiveness of introduced tree species in European forestry as some species have spread from managed forest sites into nearby natural or semi-natural habitats. Owing to different perceptions of this issue, this has led in some cases to conflicts of interest between forestry on the one hand and nature conservation on the other. Consequently, there is a crucial need for standardized methods to assess the degree of introduced forestry species' impacts. However, in spite of the new EU Regulation No 1143/2014, legislative requirements for European Union member states concerning the use of consistent and therefore comparable risk assessment approaches are lacking. In this study, we analyzed currently used approaches for the assessment of invasiveness with respect to their applicability to introduced tree species. We collected available protocols for risk assessment of introduced species in Europe and compared risk classifications by evaluating the assessment criteria for several presumably invasive tree species. Risk assessment approaches showed dissimilarities which are likely due to a lack of data and discrepancies in scoring, classification and weighting of criteria of invasiveness, such as the environmental impact or spread potential of the indroduced species. Our study illustrates inconsistencies in risk assessment approaches across European countries. Moreover it highlights the need for a standardized risk approach of introduced forestry tree species in Europe that is primarily based on empirical-scientific data, thus provides transparency and replicability. Our analysis is the first important step to improve the quality of invasiveness assessments of introduced tree species in Europe. Based on this analysis we suggest a harmonized approach that could facilitate a pan-European assessment of invasiveness of tree species.

invasiveness assessment, introduced tree sp., EU

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

9 - IUFRO Task Force on Biological Invasions in Forests

KG I - 1010 (Uni Freiburg)

IUFRO17-2021 **Douglas-fir as a plantation tree in New Zealand - invasion potential meets forest management**

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Abstract: New Zealand is a southern hemisphere country, where a high percentage of land area has been planted with exotic conifers over the last 100 years. Approximately 8% of the land area is currently covered by exotic conifers. While radiata pine (*Pinus radiata*) dominates NZ's exotic plantation forests, Douglas-fir (*Pseudotsuga menziesii*) has been increasingly planted since the 90's as a plantation, shelterbelt or woodlot species in areas where other tree-species where not favoured or were deemed as unsuitable. The presence of Douglas-fir in specific environments and the maturation of the Douglas-fir resource in the next decade paints an increasingly worrying picture in regards to the management of Douglas-fir invasions resulting from these plantings. This paper will give an overview of the evolving situation in New Zealand and provide possible approaches to manage Douglas-fir as an invasive but also productive plantation species in New Zealand. Better management approaches to minimise the possible treat from the current and future Douglas-fir resource need to account for a range of factors such as the specific traits that make Douglas-fir an invasive species, the possible dynamics of Douglas-fir invasions and the proneness of the receiving environments for tree-invasion. We provide results from a number of studies that provide quantitative data of these aspects and we synthesise to provide a better understanding of the interaction and the potential impact on plantation management and tree-invasion control in New Zealand.

Douglas-fir, tree-invasions, management,

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IUFRO17-1442 **Invasion patterns and ecological impacts of an exotic herbivore - emerald ash borer in North American forests**

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Abstract: Exotic herbivorous insects have the potential to cause significant ecological and economic damage in non-native landscapes. Specifically, emerald ash borer introduced from Asia has caused mortality of tens of millions of ash trees in North America. We assessed the invasion patterns, and direct/indirect ecological impacts of ash decline and dieback in eastern U.S. forests. Within 5-6 years of the insect detection, ash tree mortality reached ~99% in many stands with few ash seedlings and seeds. There were no relationships between ash dieback and various attributes of community composition (e.g., density, basal area, and tree diversity). Black ash dieback was faster than those of white and green ash trees. More than 50 species of native arthropods are known to be associated only with ash trees, and they may go co-extinct on the landscape. Indirect and negative impacts of ash dieback were observed on populations and communities of litter-dwelling insects. Oak, maple, and basswood trees will likely replace ash with irreversible alterations to abiotic and biotic dynamics in these forest stands.

Ecological impacts, Exotics, Fraxinus

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

93 - Silviculture for non-wood ecosystem services

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IUFRO17-333 **Comparing supply and demand of forest ecosystem services for urban and rural forests**

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Abstract: Ecosystem services (ESS) are often assessed at the landscape scale. The landscape is relevant for multiple ESS (e.g., water quality or quantity at the watershed level), but also chosen due to data or computational constraints. In forestry, the classical operational unit is the forest stand with rather homogeneous silvicultural treatment. This traditional assessment scale hardly fits to assessment opportunities of ESS at the landscape scale in a spatially explicit manner. Considering both the forest area and the surrounding land use will allow for analyzing (i) ESS on the forest area, (ii) how forest management affects ESS, and (iii) the radius and spatial characteristics of supply and demand of forest ESS beyond the forest area.
Therefore, we will analyze the interactions of manifold provisioning, regulating and cultural ESS for an urban and a rural forest in southern Germany. ESS supply and demand patterns likely differ for both forest locations. We expect a higher demand for non-wood ESS (i.e., other ESS than timber and fuelwood) in the urban forest. A previous stakeholder consultation has shown that recreation and drinking water were significantly more important than wood production in the urban forest, whereas wood production and recreation were mostly equally important in the rural forest. In that respect, we aim to analyze how forest management can adapt ESS supply to the demand patters. Thereby, we will assess demand and supply pattern within and beyond the forest area and we will quantify the degree of alignment within and between ESS categories. We will develop quantification approaches to cover the heterogeneity of ESS and scales.

ecosystem service, urban forest, forest management

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IUFRO17-2472 **A pre-commercial thinning intervention designed to reduce impacts on wildlife habitat while reaching timber production objectives more cost-effectively**

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Abstract: Thousands of hectares of young dense stands are treated every year in eastern Canada to a pre-commercial thinning where 2000 to 2500 trees per hectare are released of all other trees. This treatment is easy to implement and is proven to be an effective timber production investment. However, this drastic opening of young dense stands is also known to modify habitat characteristics required of many wildlife species in multiple ways: change in visual obstruction, species richness and abundance, vertical structure and complexity, etc. The recent commercial availability of a new kind of clearing saw, designed for top spacing, was the trigger to consider reinventing how pre-commercial thinning is performed with the intent to reduce the impact of the treatment on existing wildlife habitat characteristics while improving the cost-effectiveness of this timber production investment. A crop tree release approach was tested in a 16 years old dense hardwood stand. The treatment was designed to release only the upper half of the crown of well-formed and vigorous trees of high value species with specific instruction to leave all other stems. This resulted in a more focused silvicultural effort, leaving stems that will help in guiding the formation of a sawlog free of branches, while maintaining a high species diversity and a complex structure. In addition to leaving the stand closer to pre-treatment conditions, worker productivity showed to be increased by 200 to 400 % compared to that of traditional pre-commercial thinning, resulting in significant cost reduction. This increased productivity was attributable to both the change in the focus of the treatment and to equipment characteristics that allowed for fast and easy travel within the dense portions of the stand.

Crop tree release; clearing saw; productivity

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IUFRO17-3294 **Mycosilviculture: managing forests for the provision of fungal ecosystem services**

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Abstract: Forest fungi are a major biodiversity component of forest ecosystems and contribute to providing crucial ecosystem services (ES). Thus, edible mushrooms and truffles, which often arise from the mycorrhizal symbiosis between fungi and tree species, are among the most demanded non-wood ES worldwide as a source of wild food and recreation that may be even more valuable than timber. Forest fungi also play a key role in regulating carbon dynamics and nutrient cycling as well as stand dynamics and resilience. The interactions between environmental and anthropogenic drivers largely determine fungal diversity and the provision of related ES. As a result, changes in fungal diversity and productivity may have, ultimately, an impact on human well-being. While environmental factors such as weather conditions or site characteristics are unlikely to be managed over broad spatial scales, humans can affect fungal communities and related ES by modifying forest stand structure, dynamics and disturbance regime through silviculture and forest management. Indeed, modifying stand structure and dynamics by means of silvicultural operations can contribute to driving fungal dynamics, e.g., by affecting the allocation of carbohydrates from trees to the fungi as well as by altering the microclimatic conditions and soil water retention and availability at the stand level. Thus, "mycosilviculture" arises as a new silvicultural concept that may be defined as the art and science of controlling the establishment, growth, composition, and quality of forest vegetation for the full range of ES provided by forest fungi. Our contribution aims at presenting the latest scientific findings regarding the effect of silviculture on the provision of above- and below-ground fungal ES based on a thinning experiment in Mediterranean forests using an array of sampling methods and DNA-sequencing techniques.

Silviculture, thinning, fungi, diversity, wildfood

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

93 - Silviculture for non-wood ecosystem services

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IUFRO17-1148 **Assessing the Non timber forest products in tropical forest: case of study Imataca forest reserve Venezuela**

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Abstract: There is a clear tendency to establish the forest multi use management in tropical production forest, however it has been rarely successful, one reasons is the lack of non timber forest product (NTFP) assessment and the incompatibility of measurements of timber inventories and other products. In this context, we have developed a strategy to assess NTFP within a permanent production zone in the Venezuela. The strategy includes a rapid ethnobotanical approach, inventory of identified product using as a frame the traditional timber inventory; a particular scale to estimate dominance/abundance; multivariate analysis were also use to relate NTP species composition to the physiography. In the study area, 33 potential NTP species were found, 10 lianas, 17 trees, 4 palms and 2 forbs. They are used mainly as a medicine and for handcraft. The most common NTFP species are Eschweilera subglandulosa, Bauhinia guianensis and Uncaria guianensis, some tree species such as Carapa guianensis, Copaifera publiflora which are known for its multiple uses. The distribution of the NTFP respond significantly to the small physiography variations, being Eschweilera subglandulosa an indicator of higher places and Carapa guianensis and Manilkara bidentata more common in the lower physiography, particularly important is the variation of the abundance/dominance of species analyzed among the physiography. With this strategy, we could not only identify the potential NTFP species, but also the distribution and the relation of the species to differences in the physiography which is useful for further management strategies such as evaluate the timber harvesting compatibility.

Venezuela, Imataca, NFTP, iventory

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

92 - Concepts and assessments of forest ecosystem services and benefits

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IUFRO17-1658 **Trade-offs and synergies among multiple ecosystem services under future oil palm expansion scenarios in Indonesia**

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Abstract: Oil palm plantation has considerably changed the natural landscape of Indonesia in the past three decades. Sustainable oil palm productions for both domestic and global markets is pivotal to Indonesia's national economic development and for supporting smallholder growers' livelihoods while achieving climate change mitigation and biodiversity conservation goals. We assessed sustainability of oil palm landscape under five plausible future land use scenarios: Business as usual, Moratorium, Sustainable intensification of oil palm, Spatial plan, and, Optimum oil palm scenarios. Five key ecosystem services: carbon storage and sequestration, habitat quality, water yield, oil palm and timber production were assessed for these scenarios using a spatially explicit ecosystem service-modeling tool, Integrated Valuation of Ecosystem Services Tool (InVEST). The results show that except for the oil palm production other ecosystem services were diminished under the business as usual scenario whereas the sustainable intensification of oil palm, and moratorium scenarios ensured conservation of significant habitat quality areas and also increased carbon sequestration and storage. This suggests that there is scope for minimizing the trade-offs between oil palm development and conservation, yet all stakeholders involved including state and non-state actors have to understand the synergies among key ecosystem services to transition towards sustainable oil palm landscapes.

sustainability, landscapes, stakeholder, InVEST

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IUFRO17-807 **Quantifying and understanding spatio-temporal ecosystem services interactions in transformed forest landscapes: insights from a Patagonian biodiversity hotspot**

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Abstract: An improved understanding how ecosystem services are distributed across the landscape and how they change over time provides key information to manage multifunctional landscapes. In the south of Chile the increase of exotic forest plantation and the over exploitation of the native forest has contributed to the decrease of forest ecosystem services that provided support to local communities. We identified trajectories of ecosystem changes from 1985 to 2011 at a regional scale, in the four most important geomorphological areas. Historic land cover/land use information was used together with auxiliary data to assess selected ecosystem services with a spatial explicit model (InVEST): Provisioning (forest plantation production index), regulating (carbon storage, sediment and phosphorus retention) and cultural (aesthetic value, forest recreation) ecosystem services were quantified. While plantation production and forest recreation increased over time in all geomorphological units, regulating services showed an uneven pattern tending to decreased in time and across geomorphological units. To incorporate the demand side we defined "servicesheds" - i.e. the areas that provide a particular ES to a particular beneficiary; including local, national and global beneficiaries base on the service. We thereby not only provide base information of supply but also about its beneficiaries, crucial to manage and planning forest landscapes.

spatio-temporal, forest ESS, Patagonia

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IUFRO17-455 **Approaches and methods for ecosystem services assessment in the North of Portugal: from supply modeling to land management optimization**

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Abstract: In the last decades, ecosystems services (ES) in the North of Portugal have been assessed typically for sets of ES addressed individually based on indicators (e.g., LULC) but also through mechanistic and non-mechanistic modeling (e.g., hydrological modeling, InVEST). Economic evaluation has been applied based mostly on the combination of ES supply in biophysical units with market prices or value attributed by other techniques (e.g., avoided cost, unit value transfer). Such studies, and the approaches and methods involved, have been helpful in demonstrating the magnitude and dynamics of the supply of a series of ES in the region, both in biophysical and monetary units, and to inform regional planning and management of natural resources, such as forests. These studies have been changing the perception of stakeholders regarding forest systems and their management. Despite the importance of ES research conducted so far, there is an ongoing effort to further develop ES assessment in the region, conceptually and methodologically, namely by overcoming some of the intrinsic constraints of the approaches and methods used. Improvements intend to better integrate different ecosystem functions and services, to eliminate double counting, and to address the interactions between supply and demand of ES at several scales. The incorporation of capabilities of land-use and management optimization based on the supply and value of ES is also currently a research goal in the region. Recent developments have been based on operational research tools developed for the forest sector in the region of Bragan ça addressing ecosystem services from heuristics, multi-criteria and linear programming perspectives, expecting to solve complex spatially explicit management alternatives problems based on ES. In this presentation we will introduce these tools and their adjustment and applications in the assessment of ES in the region.

heuristics, forest ecosystem services

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

92 - Concepts and assessments of forest ecosystem services and benefits

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IUFRO17-3339 **Afforested Plantations Alter Ecosystem Services in Pampas Grasslands in Argentina**

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Abstract: Ecosystem services provide essential goods and services to human communities, but many of these services can be impacted by land-use change. In Entre Ríos province in northeastern Argentina, large-scale eucalyptus plantations are replacing ranchlands and annual crops as the dominant use. These afforested eucalyptus plantations represent a new land use in a region that historically was once part of the Pampas grassland. Favorable government policies and market conditions will likely result in the continued expansion of large-scale monocultures of even-aged eucalyptus stands with unknown consequences for multiple ecosystem services. To clarify and quantify the potential trade-offs between expanding plantations and ecosystem services, we modeled changes in pollination services, carbon sequestration, and biodiversity using InVEST ecosystem service modeling software using both primary and secondary data sources. We considered two future plausible scenarios, one representing "business as usual" based upon land-use trends from the last 10 years and a second scenario representing a significant expansion of eucalyptus, which is expected based on expanded tax incentives for forestry, and contrasted these scenarios with a 2014 baseline land use map. We also incorporated the community values of the region, based on interviews and social surveys, to capture social acceptability and local perspectives of plantations. Preliminary results suggest that the expansion of eucalyptus will cause a decline in pollination service provided by wild bees and a reduction in bird species richness, along with variable changes in soil carbon values. The degree of eucalyptus expansion drove much of the changes in ecosystem services. Results suggest that the expansion of eucalyptus plantations will likely result in the reduction of our modeled ecosystem services. Final results will further incorporate effects on water usage of eucalyptus plantations at stand and landscape perspectives.

eucalyptus, interdisciplinary, social science,

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IUFRO17-1269 **Backcasting future states to match supply and demand for ecosystem services in Slovakian regions of Podpolanie and Kysuce**

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Abstract: Ecosystems provide a range of goods and services to society. As claims for ecosystem services increase, to match the supply and demand requires consent among various interests and their coordination at the level of operational forest management. The goal of this study is therefore to assess demand and supply for ecosystem services in the future, and interactions with policy and forest management strategy. More precisely, an answer is sought to the question: which policy tools are reasonable in the combination of forest management strategies under given future desired but tolerable states of ecosystems? This is accomplished by application of the foresight method of participatory backcasting. The approach is applied to the case of backcasting regional ecosystem services in the future in Slovakia. Slovakia has undergone institutional changes in last 20 years that are represented by selected regions of Podpolanie and Kysuce, which vary in current state of the forests, their forest classes, their tree composition, and their ownership structure. Bounded by a sustainability vision of forest management, regional ecosystem services in 2044 are backcast against three future scenarios developed for each region. This all is possible with the help of participatory workshops organized with nine and 14 participants in the Podpolanie and Kysuce region respectively. The backcasting outcome illustrates robust policy tools or actions stretching from financial support to law adjustments, which are subsequently combined into suitable forest management strategies for each region analyzed. Selected forest management strategies (e.g., environmental strategy, payments for non-market services strategy) represent potential pathways towards achieving future desired but tolerable states of ecosystems.

backcasting, FM, ES, Slovakia

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IUFRO17-1664 **Silviculture, Climate Change and Ecosystem Service Provision. Simulation Studies in Two Contrasting German Forest Landscapes**

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Abstract: In contrast to the traditional situation, modern societies demand forest management to provide a broad range of ecosystem services beyond wood or biomass production (like recreation, water supply, C-sequestration, biodiversity). Provision of such services in relation to forest management has only recently moved into the focus of broad quantitative research activities (cf. Biber 2015). This challenge to forest management is intensified by the ongoing climate change which influences forest productivity as well as vulnerability. State of the art climate sensitive forest simulation models which flexibly cover a broad range of silvicultural treatments as well as measures for the provision of many relevant ecosystem services from stand to landscape level are important tools for optimizing forest management given these challenges. In the framework of the EU H2020 project ALTERFOR, the authors are responsible for forest simulation scenarios in two different German case study landscapes (about 100 000 ha each). Directly related to the outcomes of our ongoing work in ALTERFOR, we delineate essential model features for a multidimensional scenario analysis of ecosystem services within complex forest landscapes. We also pinpoint core themes of our ongoing model development to improve model flexibility towards a large variety of future climatic boundary conditions.

Service Provision,Silviculture,Climate,Scenarios

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

24 - Growth and Dynamics of Pine in Mixed Forests

K 8 (Konzerthaus Freiburg)

IUFRO17-3940 **Mediterranean mixed pine forests: the role of stand density on growth efficiency and pine decline**

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Abstract: Mediterranean forests are suffering important climatic and management changes during the last decades including higher level of aridity, irregularity in rainfall patterns and abandonment of silviculture. All these factors are leading to modification in growth efficiency, forest decline and tree mortality due to a complex processes caused by biotic and abiotic factors acting as multipliyers of individual effects. By using stand and tree level analysis, I'll insight on the following relevant aspects: (1) Tree growth pattern in mixed forests under different phytosanitary conditions, (2) Impact of aridity on mixed forests growth, (3) Interaction between stand density and aridity and its effect on tree growth, (4) Tree social status and competition (inter and intra specific) level impact on tree growth and (5) Specific growth efficiency in mixed stands at stand and tree level. Finally, analysis to determine if species proportion or stand structure are the key factor on mixed stand proportions will be done.

mixing effect, yield, basal area, drought

K 8 (Konzerthaus Freiburg)

IUFRO17-4085 **Growth partitioning and growing space efficiency of eastern white pine (Pinus strobus) in mixed-species forests of the northeastern United States**

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Abstract: Eastern white pine (Pinus strobus L.) is an economically, ecologically, and culturally-important species in forests of northeastern North America. However, concerns have arisen about the sustainability of this resource. The majority of eastern white pine volume and biomass is growing within complex, naturally-regenerated mixed-species forests, where the species often occurs as a canopy dominant or super-dominant. We used a recently-developed mixed-species density measure, utilizing a functional trait-based generalization of Reineke's stand density index, to explore patterns of growing space partitioning and growing space efficiency in these stands. Although challenging to interpret due to the observational nature of the data, and the inherent complexity and variability of stand structures, the results suggest complementary resource use, especially when eastern white pine occurs in upper crown positions. The results have implications for maintenance of pine in these stratified mixtures.

Stand density, functional traits, land-use history

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

92 - Concepts and assessments of forest ecosystem services and benefits

KG I - 1010 (Uni Freiburg)

IUFRO17-863 **Considering Ecosystem Services and their Uncertainties in Forest Management Planning**

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Abstract: Forest composition and structure have an important influence on the level of ecosystem services, a forest may provide. Moreover, high forest compositional diversity may provide effective buffer against uncertainty. The presentation investigates, how the demand for multiple ecosystem services (multifunctionality) has an impact on the optimal forest composition. Forest composition is addressed in the form of portfolios of tree species and stand types. Simultaneously, the study tests the influence of integrating uncertainties. Uncertainty is considered through uncertainty spaces, as known from robust, non-stochastic optimization. The results are finally compared with pure economic optimization in order to quantify possible opportunity costs through considering multiple ecosystem services.

forest planning, uncertainty, robust optimization

KG I - 1010 (Uni Freiburg)

IUFRO17-1366 **Mitigating forest biodiversity and ecosystem service losses in the era of bio-based economy**

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Abstract: Forests play a crucial role in the transition towards a bioeconomy by providing biomass to substitute for fossil-based materials and energy. Increasing forest harvest levels to meet the needs of the bioeconomy may conflict with biodiversity protection and ecosystem services provided by forests. Through an optimization framework, we examined trade-offs between increasing the extraction of timber resources, and the impacts on a biodiversity and non-wood ecosystem services, and investigated possibilities to reconcile trade-off with changes in forest management in 17 landscapes in boreal forests. A diverse range of alternative forest management regimes were used. The alternatives varied from set aside to continuous cover forestry and a range of management options to reflect potential applications of the current management recommendation. These include adjustments to the number of thinning, the timing of final felling and the method of regeneration. Increasing forest harvest level to the maximum economically sustainable harvest had a negative effect on the habitat suitability index, bilberry yield, dead wood diversity and carbon storage. It resulted in a loss in variation among landscapes in their conservation capacity and the ability to provide ecosystem services. Multi-objective optimization results showed that combining different forest management regimes alleviated the negative effects of increasing harvest levels to biodiversity and non-wood ecosystem services. The results indicate that careful landscape level forest management planning is crucial to minimize the ecological costs of increasing harvest levels.

Bioeconomy, Trade-off analysis, ecosystem services

KG I - 1010 (Uni Freiburg)

IUFRO17-379 **Spatial Assessment of Differences in Ecosystem Functions and Services on Forest Air Purification in South Korea**

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Abstract: Despite increasing interest in ecosystem services, the difference between ecosystem functions and ecosystem services is still not clearly understood by policy makers and stakeholders. Ecosystem functions can be understood as the quantified amount of an ecosystem's role in a natural process, while ecosystem services are the requantification of the ecosystem functions by factoring in environmental conditions and human needs based on social perspectives. Differences between ecosystem functions and services were presented in terms of air purification of a forest ecosystem. Forest volume growth was employed to quantify the pollutant absorption capacity of a forest and was indicated by the natural functions (NF) for air purification by a forest ecosystem. Air pollutant density was applied to the assessment of the environmental services (ES) of forest ecosystems. Furthermore, the environmental social services (ESS) of forest ecosystems were assessed by including population density considerations. This study found differences in NF, ES, and ESS in relation to pollutant and population density; while NF was quantified without a close relationship to pollutant and population density, ES and ESS were found to reflect pollutant and population density. The results imply that the ecosystem services of forest resources for air purification are high where the pollutant and population densities are high, while the ecosystem functions of forest resources for air purification depend solely on forest conditions and not on the density changes of air pollutants and population. This study suggests that the differences in NF, ES, and ESS are important factors to be understood and considered in the decision-making process for ecosystem services. When considering human needs and surrounding environmental conditions, decision makers should utilize the ES and ESS concepts.

forest, ecosystem service, ecosystem function

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

92 - Concepts and assessments of forest ecosystem services and benefits

KG I - 1010 (Uni Freiburg)

IUFRO17-4002 **Green infrastructures for human well-being in European forest landscapes**

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Abstract: Green infrastructure (GI) is an approach in forest planning and management to meet diverse societal needs. In this study we identified and mapped different land covers as GI in forest landscapes important for people in different contexts. What type of forests delivers ecosystem services (ES) important for human wellbeing? What types of forest management are important to maintain the provision of ES? In total 1600 structured interviews were made in Sweden, Latvia, Belarus and Russia. Respondents were randomly selected in urban and rural areas. They were asked to select the most important landscape benefits for their personal wellbeing from a predetermined list, and to identify land covers that provided those benefits. The results show that the most important land covers for the majority of respondents were mature pine forests, old-growth forests, wood-pastures, lakes, and rural farmsteads. To maintain functional GI at least three land management strategies should be kept: to diversify forest management in order to maintain attractive forests as a source of multiple ES for human well-being; to develop functional protected area networks to sustain the provision of ES associated with old-growth forests; and to maintain traditional agroforestry practices in wood-pastures.

Baltic Sea Region, ecosystem services

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

206 - Operational methods for monitoring and assessment of forested landscapes

KG I - 1098 (Uni Freiburg)

IUFRO17-95 **Practical data fusion: Using forest inventory data to improve thematic inferences from broad-scale landscape pattern analysis**

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Abstract: Broad-scale landscape pattern analyses typically use land cover maps that sacrifice thematic detail to gain required consistency over large regions. This enables assessments that would not otherwise be feasible, but it limits the thematic detail of inferences that can be made from the assessments. In the United States national assessments, we wanted to incorporate thematic information from the national forest inventory system, but strict spatial fusion was problematic because the inventory definition of forest (as a land use) was different from its forest cover and pattern definition. Instead, landscape pattern metrics were mapped as spatially-continuous descriptors of neighborhood context, and each inventory plot location was assigned new neighborhood pattern attributes from spatial overlays. Estimation then used the thematic details and statistical design of the forest inventory system. In practice, the keys to data fusion were defining and mapping patterns as continuous fields so that they could be downscaled to any specific location, and making properly-structured inferences that took advantage of the strengths of both data sources. This presentation illustrates the approach using results obtained for the 2020 United States national report on forest landscape pattern status and trends.

pattern; inventory; data fusion; assessment

KG I - 1098 (Uni Freiburg)

IUFRO17-1190 **Assessment of forest ecosystems: support from operational spatially explicit methods**

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Abstract: The preservation of biodiversity has become a major challenge for sustainable development at national, European (Natura 2000 and Habitats Directive) and international levels (Convention on Biological Diversity, 2011-2020). In answer to these urgent conservation needs; operational methods are needed to map terrestrial vegetation and produce high resolution detailed habitat mapping, including habitat condition. In Europe in particular, there is the ambition to use detailed habitat mapping as a national strategic spatial tool in answer to biodiversity monitoring, conservation planning, and related ecosystem services and to report on the conservation status of habitat and species of community interest within the EU. The use of RS and related techniques is a must nowadays to obtain a synoptic view of the natural environment. Increased access to satellite imagery and new developments in remote sensing data analyses can support biodiversity conservation targets by stepping up monitoring processes at various spatial and temporal scales. More satellite imagery is indeed becoming available as open data, while remote sensing based techniques to capitalise on the information contained in spatially-explicit species data, such as Global Biodiversity Information Facility (GBIF), are developing constantly, and offering a plurality of application options. Current free and open data policy will have a dramatic impact on our ability to understand how biodiversity is being affected by anthropogenic pressures, while improving the capability to predict the consequences of changes in drivers at different scales. The work will provide an overview on methods and capabilities on forest remote sensing applications. We aim to highlight how coupling remote sensing and ground observations with adequate models can provide operational solutions towards a better understanding and management of natural systems in particular forests.

Biodiversity, remote sensing, spatially explicit

KG I - 1098 (Uni Freiburg)

IUFRO17-1212 **Open Foris Initiative: Enabling multi-purpose forest monitoring, reporting and management.**

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Abstract: The United Nations Food and Agriculture Organization (FAO) established Open Foris Initiative to support countries in their efforts to develop National Forest Monitoring Systems (NFMS). Free and open source software tools developed within the initiative support the whole process of NFMS from survey design and data collection to the analysis and reporting of the results.

The Open Foris tools have been already used to conduct several national forest inventories and their flexibility has attracted users from other sectors as well. Initially piloted in five countries and released at the 24th World Congress of the International Union of Forest Research Organizations (IUFRO) in Salt Lake City, US in 2014, the tools are now in use in more than 30 countries and their development is continuing in close collaboration with partners such as Google and NASA.

This presentation will provide insight to the current status and future roadmap of the Open Foris Initiative and the tools developed within it. It will also highlight how different actors have used these tools to enhance their knowledge on environment, to fulfill their reporting obligations and to support sustainable management of natural resources

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Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

206 - Operational methods for monitoring and assessment of forested landscapes

KG I - 1098 (Uni Freiburg)

IUFRO17-1265 **Priority areas for strict forest reserves: identifying hot spots with high conservation value**

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Abstract: One ratified goal of the German National Biodiversity Strategy is to increase the proportion of unmanaged forest to five percent of the total and ten percent of the state forest area, respectively, with implementation at the Federal State level to be completed until 2020. Previously, strict forest reserves have frequently been designated in areas unviable for forestry, which are not necessarily of high conservation value and strongly biased towards poor site conditions.
The aim of this study was to spatially identify a coherent and representative network of forest patches of high conservation value within state's forest of Baden-Württemberg for optimal future reserve selection.
To ensure high conservation impact whilst minimizing costs, these areas were selected using optimization algorithms (MARXAN) in a systematic conservation planning framework. One of its requirements is the definition of quantitative targets for specific selection criteria, which in our study were representativeness (regarding topography, climate, site conditions and forest type) and conservation value (e.g. age class, naturalness, structural complexity, habitat continuity). As conservation targets are often policy-driven and scientifically ill-defined, a sensitivity analysis was carried out to evaluate target-selection effects on the variability of the resulting conservation area network. Different scenarios were modelled, in which selection criteria were weighted differently, their target values gradually increased and resulting outcomes subsequently assessed by a range of metrics (e.g. irreplaceability, total area, connectivity).
While target modification affected the selection probability of patches with intermediate quality, top conservation hotspots showed a high persistence across scenarios.
The results allow decision-makers to effectively maximize conservation targets while reaching the area goal.

Systematic conservation, forest protection

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IUFRO17-1121 **Connecting Natura 2000 forest sites: linkages, bottlenecks and priorities for conservation and restoration**

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Abstract: Sustaining connectivity between protected areas, and between forest habitat areas in the unprotected landscapes, is one of the key objectives of forest green infrastructure. There is, however, a lack of spatially explicit guidelines that help to (i) identify the key linkages at wide spatial scales and to (ii) pinpoint where to best concentrate efforts for the conservation or restoration of forest green infrastructure for connectivity. Here we show how a combination of recent methods and tools for connectivity analysis can deliver improved insights on the location and quality of forest connectors, on the connectors to prioritize in different conservation or restoration scenarios, and on the bottlenecks (weak points) that can exist along these connectors. We illustrate the approach with an analysis for all continental Spain (500,000 km2) that focuses on the national network of Natura 2000 forest sites, uses high spatial resolution data to characterize the heterogeneity and resistance of the landscape matrix to forest species movement, and accounts for the potential patterns of transboundary connectivity. We characterize the conditions of the areas traversed by different types of connectors, and discuss the related implications for forest management planning and for the restoration of the intermediate landscapes in between forested habitats.

Natura 2000, green infrastructure, connectivity

KG I - 1098 (Uni Freiburg)

IUFRO17-1034 **Analysis of ecological connectivity to improve design of greenways as ecological corridors**

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Abstract: European Greenway developments typically 'recycle' disused transport corridors into multi- use, non- motorised public infrastructure. Prior to development, such corridors are often regained by wildlife. This project researches the potential of Greenways as ecological corridors. A baseline map of habitats occurring along the proposed international Sligo, Leitrim, Northern Counties Railway (SLNCR) Greenway project is digitised using ArcGIS. The mapped area, covering 70km2 is ground-truthed and assessed for accuracy. The mapping illustrates a dominance of semi natural woodland and grassland habitat, interspersed by land use intensification. A linear woodland density of 10.4km/km2 is mapped and condition assessments are carried out. Results indicate the linear woodland surveyed is of high significance, most likely due to the 'Green Lane' effect of the former railway. Semi-natural habitats such as woodlands and hedgerows occurring within the study area are analysed for connectivity using Morphological Spatial Pattern Analysis. The results of connectivity analysis are then combined with habitat data and six distinct landscape classes are identified along the Greenway route using multivariate analysis. These landscape classes are interpreted for the development and maintenance of the Greenway to ensure semi- natural woodland connectivity is not lost and the development is complementary to its natural surroundings.

Greenway,ecological corridors, MSPA.

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

206 - Operational methods for monitoring and assessment of forested landscapes

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IUFRO17-1408 **Does the forest fragmentation depend on the long-term forest history? Testing the 'landscape hypsometric curve' approach**

Ziolkowska, E.* (1); Kozak, J. (1); Kaim, D. (1); Dobosz, M. (1); Kolecka, N. (1); Ostafin, K. (1); Vogt, P. (2)

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Abstract: Understanding the causes and consequences of changes in forest cover and its fragmentation is critical to preserving ecosystem functioning. We used long-term (since the 19th century) and large-scale data on historical forest cover in the Polish Carpathians from the FORECOM project (http://www.gis.geo.uj.edu.pl/FORECOM/) to identify trajectories of forest fragmentation. Past forest cover was reconstructed using historical maps (the Austro-Hungarian Second Military Survey Map for 1860s; the Polish Military Map for 1930s; and the Polish Topographic Map for 1970s), while the current forest cover was based on the national database of topographic objects for Poland. We analyzed forest cover changes in 127 randomly selected circular test areas. Forest fragmentation was quantified with the GuidosToolbox software using measures based on a 'landscape hypsometric curve', i.e., the hypsometric curve for the Euclidean distance distribution for a forest / non-forest binary map. This approach allows to account for different fragmentation aspects, such as amount, division, and dispersion of forest patches, simultaneously. Despite general increase in forest cover, forest fragmentation showed divergent trajectories, i.e., a decrease between 1860s and 1930s (in 57% of test areas), and an increase between 1930s and 1970s and between 1970s and 2010s (in 58% and 72% of test areas, respectively). We further applied exploratory regression analysis to identify predictors determining the current forest fragmentation and its changes over time, where predictors were defined as measures related to the total area of forest patches and its changes in analyzed time steps (e.g., forest increase / decrease rate), or other environmental variables (e.g., elevation, slope).

Fragmentation index, historical maps, Carpathians

KG I - 1098 (Uni Freiburg)

IUFRO17-265 **Analyzing forest landscapes: Digital image analysis based on geometric concepts**

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Abstract: This study illustrates a series of methods for the description and quantitative analysis of a variety of image object attributes, available in the free software GuidosToolbox (http://forest.jrc.ec.europa.eu/download/software/guidos). All methods are based on geometric concepts only and thus applicable to any kind of raster data and at any scale, for individual analysis as well as batch-processing. They are designed to detect and quantify several morphometric image attributes including pattern, connectivity, fragmentation, cost, distance, naturalness, and change analysis. The portable software collection is complemented by generic image processing routines, exporting data as GoogleEarth image overlays, GDAL command line tools, and the powerful OpenEV raster/vector data viewer. Sample applications from a variety of environmental application fields complement this overview.
Reliable, generic, and quantitative assessment schemes provide an integrative and solid reference framework. They permit describing the spatial configuration, the detection of local hotspots, and quantifying changes, a prerequisite for meaningful statistical analysis. These recent developments are of particular interest for landscape planners and policy decision makers to support operational monitoring needs and to provide tools for measuring, and thus evaluating the progress in projects related to landscape dynamics and ecosystem services.

forest monitoring, spatial analysis

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

58 - Managing forests for Biodiversity and Resilience

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1630 **Even-aged rather than uneven-aged forest management promotes the regional biodiversity of multiple taxa in European beech forests**

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Abstract: Habitat heterogeneity can enhance biodiversity, but the generality of this relationship is debated. For managed temperate forests conservationists and policy favour fine-grained uneven-aged management over the traditional more coarse-grained even-aged management, assuming that within-stand habitat heterogeneity enhances biodiversity. There is, however, little empirical evidence to support this assumption.
We investigate for the first time how differently grained forest management systems affect the biodiversity of multiple taxa above- and belowground across spatial scales. We further explored whether mixing of management systems enhance larger scale biodiversity.
Gamma-diversity was up to 77% higher in even-aged than in uneven-aged forests for six of the 15 taxa, for at least one of the three Hill-numbers, while eight groups showed no difference. Only bacteria showed the opposite pattern. A higher gamma-diversity of even-aged forests was also found for forest specialists and saproxylic beetles.
Between stand beta-diversity was higher in even-aged than in uneven-aged forests for one third (all species) and half (forest specialists) of all taxa, driven by environmental heterogeneity between age classes, while alpha-diversity showed no directional response across taxa and for forest specialists.
Mixing of both management types in hypothetical landscapes did not enhance biodiversity in 13 of the 15 taxa. This indicates that uneven-aged forests comprise a subset of the species assemblage of even-aged beech forests.
Our results show that the grain of forest management affects biodiversity at the regional but not at the local forest stand scale. We conclude that a mosaic of different age-classes is more important for regional biodiversity of managed forests than high within-stand heterogeneity which dilutes environmental variability. We suggest reconsidering the replacement of even-aged management in temperate forests.

Spatial grain, forest management, multitrophic

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1163 **A systematic approach to reviewing biodiversity effects of active forest conservation**

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Abstract: Loss of biodiversity even in set asides increasingly evokes debates about active habitat management in protected forests. The literature contains much evidence that indicates how the biodiversity of forest reserves could be affected by active interventions. However, this evidence is heterogeneous and a systematic approach may be needed when reviewing it. The rigor and transparency of systematic reviews is intended to minimize bias and permit quantitative and repeatable evaluation by means of meta-analysis. In 2014, the Mistra Council for Evidence-Based Environmental Management (EviEM) initiated an assessment of how the biodiversity of forests set aside for conservation or restoration may be affected by various forms of active management. First, we produced a systematic map of the available evidence. Using subsets of the 812 studies in the systematic map, we have proceeded with full systematic reviews of two subtopics: how forest biodiversity is affected by manipulation of (1) the quantity and quality of dead wood, and (2) the pressure of grazing/browsing by wild or domestic ungulates. We expect that our synthesis of the results has the potential to set a standard for organizing the evidence base used by forest conservation managers worldwide.

Systematic review, Forest set-aside

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1535 **Rethinking forest resilience through colonization and emergance rates of saproxylic beetles**

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Abstract: Ecological resilience in managed forests depends on both colonization and emigration rates in residual habitats. Habitats and species that maintain relatively high ratios of colonization to emergence will likely contribute to greater resilience of managed forests. Habitats and species with low colonization and emergence rates will contribute little to forest resilience as these species are predicted to become locally extinct as part of an extinction debt. We compared annual colonization and emergence rates of saproxylic beetles associated with cut stumps in a replicated biomass removal trials where surrounding deadwood was either left in place (cut-to-length clearcutting) or removed (whole-tree harvesting) between 2015-2017. We collected species-specific colonization and emergence rates for >126 species using both emergence traps and sticky cards. We found little evidence that reducing deadwood volume by ca. 60 m3/ha had impacts on colonization and emergence rates of stumps by saproxylic beetles. However, it is clear which species can be classified as 'dynamic' (those with high levels of colonization and emergence) or 'static' (species with little turnover) and that both rates change as stumps degrade. Species-specific parameters are thus clearly useful for quantifying forest resilience and identifying which components of biodiversity may require additional conservation efforts in managed forests. We have incorporated these species-specific responses into a practical framework that can be used to discuss forest resilience outside of the idea of 'return-time' to pre-disturbance conditions which may be unwarranted under future climatic and landscape changes.

beetles, colonization, resilience, deadwood

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

58 - Managing forests for Biodiversity and Resilience

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-4028 **Epiphytic lichens as indicators of sustainable forest management**

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Abstract: Many countries require sustainable forest management (SFM) practices either through legislation and/or certification which has led to an increase need for indicators of ecosystem integrity. Epiphytic lichens have been shown to be excellent indicators of environmental change in many forested regions of the northern hemisphere. Here we present a synthesis of our research on the distribution of epiphytic lichen diversity with a focus on calicioids and cyanolichens at multiple scales in Canada. We also assess the effects forest management on species diversity using experimental and chronosequence approaches. At a national scale, using over 6000 observations, we identified 5 biodiversity hot spots for epiphytic cyanolichens in Canada. Our chronosequence studies show that epiphytic cyanolichen diversity is not necessarily associated with stand age while calicioid lichens are. Our silviculture systems experiments show that maintenance of forest patches in managed units can maintain epiphytic lichen diversity. However, recovery of epiphytic lichen diversity following clearcuts is slow, only about 10% after 3 decades. These findings suggest that no single forest management practice will satisfy the requirements of all epiphytic lichens. A combination of spatially explicit predictive tools and a good understanding of species response to disturbance are essential to develop best management practices.

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-1967 **More than trees: a European scientific network to assess the relationships between forest structural heterogeneity, multi-taxon biodiversity, and carbon storage**

Burrascano, S. (1); Antonini, G. (2); Bouget, C. (3); Campagnaro, T. (4); De Andrade, R. B. (1); Fuhr, M. (5); Gosselin, F. (3); Janssen, P. (5); Maggi, O. (1); Mattioli, W. (6); Nascimbene, J. (7); Odor, P. (8); Paillet, Y. (3); Sabatini, F. M.* (9); Sitzia, T. (4)

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Abstract: Managing forests sustainably is important to preserve biodiversity and the services it underpins, above all climate change mitigation through the storage of carbon in woody biomass. Biodiversity conservation and carbon storage strictly depend on forest structure, and many scientists advocate for a higher degree of structural complexity in order to increase the provision of these ecosystem services.
However, a thorough understanding of the trade-offs and synergies between forest biodiversity, structure and function is still lacking especially due to the scattered and inadequate information on the distribution of forest biodiversity, whose sampling and monitoring are particularly complex and costly.
By establishing a network of scientists who collected data in European deciduous forests, we were able to create a dataset including information on forest structure and six taxonomic groups (vascular plants, lichens, bryophytes, fungi, beetles and birds) for more than 350 sampling units across France, Hungary and Italy.
We used these data to test the following hypotheses: i) a higher degree of forest structural heterogeneity results in higher levels of multi-taxon biodiversity; ii) forest stands containing a high amount of carbon stored in tree aboveground biomass are also those hosting a high degree of multi-taxon biodiversity.

biodiversity, structural complexity, carbon stocks

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3408 **Responses of dead-wood dependent beetles to continuous-cover forestry**

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Abstract: North European forestry has since 1950s been characterized by forest regeneration through clear cutting, with subsequent top-soil preparation and seeding or planting mostly with conifers. This regime, accompanied by routine removals of many legacy elements, now covers most of the forested landscape in this region. Consequences on biodiversity are many, as evidenced by national Red Lists that in Finland and Sweden contain hundreds of threatened forest specialists. Continuous-cover forestry - where at least half of a stand is covered by mature or near-mature trees throughout the logging rotation - has been proposed to support these species in managed forests. Its functioning in this respect, however, is relatively poorly understood. We therefore sampled dead-wood dependent beetles in replicated Scots pine stands that represented a continuum from clear cuts to different techniques of partial cutting to unharvested mature forest ("control"). Our sampling covered one year before and three years after experimental logging operations. We will present results about beetle community-level responses to the logging techniques and to certain structural features of stands, notably parameters about dead wood and tree-species mixture.

Deadwood, diversity, gap, retention, selection

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

58 - Managing forests for Biodiversity and Resilience

Rolf Böhme Saal (Konzerthaus Freiburg)

IUFRO17-3965 **Retention harvesting promotes resilience of boreal mixedwood forest biodiversity by retaining ecosystem memory of historical wildfires**

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Abstract: Biological legacies from pre-disturbance environment provide a sort of 'ecosystem memory' (EM) that guides post-disturbance reorganization toward the variation of pre-disturbance baselines. Therefore, the amount and quality of EM left after a disturbance directly influence resilience of the ecosystem. We investigate if ecological patterns established by historical wildfires in boreal mixedwood forest may confer biodiversity resilience after variable retention harvesting that occurred up to three centuries after the fire events. We first demonstrate that fires history over the last 300 years is related to pre-harvest tree basal area with longer times since high severity fire associated with proportionally higher basal area of shade tolerant softwood species than shade intolerant hardwoods. Second, we show that pre-harvest species composition of seven biotic assemblages (bryophytes, herbs, shrubs, tree regeneration, songbirds, spiders, and carabid beetles) reflects pre-harvest basal area established by fire history. Finally, we compare the importance of species-specific pre- and post-harvest basal areas for explaining the structure of these seven assemblages at two, five and ten years after harvest. Pre-harvest basal area had a persistent significant effect on all assemblages up to ten years after harvest. Pre-harvest basal area had stronger effect than post-harvest basal area on post-harvest understory plant and carabid beetle assemblages, but the opposite was true for spiders, songbirds and trees. We detected EM effects in all sampling years after harvest but temporal patterns varied according to taxa. Thus, post-harvest EM effects related to fire history are stronger for understory plants than for animals and can persist at least ten years after variable retention harvest. We suggest that management of biological legacies to increase post-disturbance EM will increase overall resilience and sustainability of these mixedwood forests.

Ecological memory, EMEND, Arthropod, Plant, Bird

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

72 - Oak forests and management for different ecosystem services

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2836 **Ecology and silviculture of four important oak tree species in East and South Asia: a review**

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Abstract: In Asia, oak forests are disappearing rapidly in many countries due to diseases, over-exploitation, desertification, forest fire, and destruction of natural habitats by humans. There are hundreds of oak species in Asia, but very few were adequately studied. A comprehensive review of silviculture and ecology of Asian oak species is warranted to promote restoration and conservation of Asian oak forests. Therefore, we have selected major oak species from East-Asia (Quercus mongolica; Quercus wutaishansea) and South-Asia (Quercus leucotrichophora; Quercus griffithii). We have searched literature published in English and local languages in national repositories, ISI Web of Knowledge, CAB-Abstracts, and Google Scholar. Most studies focused on the autecology and botanical characteristics. However, studies on silvicultural attributes such as challenges in natural regeneration and nursery propagation, techniques of planting and restoration, influences of silvicultural interventions (e.g. thinning and pruning) on tree growth and quality were rare. Studies on conservation status and ecosystem services were also scarce. We would like to present our final results of the review in this conference. We believe our timely review on these oak species will help foresters and researchers to earmark future areas of research related to conservation and management of forests dominated by these oaks.

Oaks of Asia,regeneration,restoration,biodiversity

K 2-4 (Konzerthaus Freiburg)

IUFRO17-821 **The silviculture of restoring oak woodlands and savannas**

Dey, D.* (1)

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Abstract: Variability in historic fire regimes in eastern North America resulted in an array of oak natural communities that were dominant across the region. In the past century, savannas and woodlands have become scarce due to conversion to agriculture, or development of forest structure in the absence of fire. Their restoration is a primary goal for public agencies and conservation organizations. Although they can be restored with a long-term regimen of prescribed burning, a combination of fire, timber harvesting and forest thinning produces the desired structure and composition more efficiently. Prescribed fire is useful for sustaining oak savannas and woodlands, but it must be used judiciously to minimize timber damage and decreases in value. Integrating fire within a modified shelterwood approach promotes competitive oak reproduction and is flexible to produce savannas or woodlands. Sustaining these communities requires the replacement of the overstory during periods of no fire.

restoration, oak, silviculture, fire, shelterwood

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2152 **Actions to mitigate the biodiversity loss in oak habitats in Southern Sweden**

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Abstract: The oak-dominated forests of northern Europe have experienced dramatic declines due to agriculture, urbanization, and conifer-dominated production forestry. These losses have had a substantial negative impact on biodiversity due to the large number of forest species which depend on oak and the environments oak-dominated forests provide. Here we present the evaluation of two actions that could mitigate these negative impacts on bird and saproxylic beetle diversity in southern Sweden: Oak production forests and retention of old oaks in spruce plantations. Though production oak forests cannot replace the habitat provided by protected oak forests, these stands do appear to provide conditions consistent with the habitat and resource requirements of a diverse cross-section of bird species, including species of conservation concern. Retaining oaks in forest plantations can increase the diversity of oak-associated beetles at the landscape scale. But, since many oak associated beetles depend on relatively high levels of insolation, management of retained oaks requires the periodic clearing of encroaching trees. In summary, both production oak forests and retained oaks thus have the capacity to make a positive contribution to biodiversity conservation, as well as providing a diverse range of goods and services to society.

Birds, saproxylic beetles, Quercus, biodiversity

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

72 - Oak forests and management for different ecosystem services

K 2-4 (Konzerthaus Freiburg)

IUFRO17-770 **Regeneration of deciduous oak (Quercus) species in temperate Europe under near-natural conditions, and implications for management**

Reif, A.* (1)

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Abstract: Topic: A number of factors influence the regeneration patterns of the central European deciduous oak species (Pedunculate oak, Quercus robur; Sessile oak, Qu. petraea; Downy oak, Qu. pubescens), including light supply; predation of acorns; browsing of leaves; pests and pathogens; competition with ground vegetation; late frost; and water supply including inundation. All these factors are interrelated in a complex way.
Method: Review combined with own studies.
Results: Under natural conditions, dry sites and long vegetation periods provide these sites conditions, resulting in forest communities dominated by oak ("Quercetum"). Pedunculate oak is additionally able to tolerate long-lasting flooding, establishing as long-lived pioneer after severe inundations with erosion and sedimentation processes. In cultural landscapes, oak establishment can be facilitated through wood pasture.
Conclusion: The germination and successful establishment of the central European deciduous oaks depend from an at least temporarily open or absent canopy, and an open ground vegetation. Their regeneration seems to be an episodic process: Long-lasting phases without successful regeneration change with short phases of successful establishment of a new oak generation. The central European deciduous oak species must be classified as light-demanding, stresstolerating, long-lived pioneers.

Regeneration, deciduous, oak, Europe

K 2-4 (Konzerthaus Freiburg)

IUFRO17-2857 **Oak natural regeneration in Scots pine (Pinus sylvestris L.) stands in Poland**

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(1) Forest Research Institute, Raszyn, Poland

Abstract: Spontaneous recruitment of deciduous tree species into Scots pine stands has been observed in Central Europe. Oaks are not pioneer trees, their regeneration in pine stands is the result of zoochory. We focused on the establishment of oak natural regeneration in pine stands of different age (0-140 year old). We wanted to know which of the environmental factors influence the quantity and quality of oak regeneration.
The study was conducted in 15 pine stands in north-eastern Poland. We established 300 concentrated circular plots in pine stands of different age.
Oak regenerated in all age classes of pine stands and was the key element in the phase of seedling and saplings. Number and occurrence of oak regeneration depended on site conditions. Frequency of bilberry and grasses negatively influenced the establishment of oak regeneration. Stand species composition did not affect oak seedling frequency. However, oak sapling occurrence was higher under pine canopy. Hornbeam and European larch negatively influenced the occurrence of oak saplings.
Oak regeneration should be used to converse Scots pine stands of all age classes into mixed forests. Even if oak will not be the main tree species in the upper stand layer it will play important role in the forest ecosystem.

conversion, Pedunculate oak, age classes, zoochory

K 2-4 (Konzerthaus Freiburg)

IUFRO17-1037 **Long-term oak regeneration dynamics in southern Sweden (1923-2015)**

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Abstract: Oak dominated forests are decreasing worldwide and regeneration problems are often considered a major factor. In southern Sweden the standing volume of oak has increased drastically from 1923 to 2015, seemingly contradicting the general trend. However, this does not necessarily reflect oak regeneration success. We used the Swedish National Forest Inventory (NFI) to analyse changes in oak occurrence of different diameter classes from 1923 to 2015, with a main focus on oak saplings (>1.3 m tall and <5 cm dbh). We found that larger size classes have increased in abundance, while smaller seem to have decreased. We put trends in relation to major population changes of the dominant browsing species (moose and roe deer) during the last 56 years. Oak is a preferred species by browsers, and high browsing pressure is expected to inhibit sapling growth and reduce survival. Furthermore, we investigated the impact of forest composition, site productivity, and forest density on oak occurrence. This study contributes to a better understanding of the long-term regeneration dynamics of oak in southern Sweden and elsewhere.

Quercus;regeneration;forest history;NFI;browsing

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

72 - Oak forests and management for different ecosystem services

K 2-4 (Konzerthaus Freiburg)

IUFRO17-3081 **Trade-offs in ecosystem services supply from Himalayan Oak forests: Global conservation targets vs. local livelihoods needs**

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Abstract: We quantified and compared the supply of provisioning ecosystem services (ES) and carbon stock, a regulating ES, from Oak and other vegetation formations (Grassland, Pine, and Pine-Oak) in Central Himalaya, India. We found that Oak forests (covering 38.5% of total 57516 ha of the study area) were the most important vegetation formation supporting local livelihoods as well as regulating ES supply and an increase in the proportion Oak cover in the landscape would lead to limited trade-offs in ES from other vegetation formations.

Provisioning ES derived from the studied vegetation formations as well as their extraction methods were assessed through a structured social survey in 702 households of 19 villages. Forest carbon stock was estimated through field measurements and analysed using site and species-specific allometric equations.

The net carbon stock was significantly higher in Oak forests (378.3 Mg/ha) than Pine (89.6 Mg/ha) and other vegetation formations. A similar trend was observed in provisioning services with dense Oak forests contributing the maximum quantity and number of ES. We estimate a 51% increase in carbon stock, 88% increase in non-wood forest products, and 44% increase in fodder availability if area under Oak forests was increased.

Potential trade-offs in ES supply with changes in land-use, presented in the study, can serve as baseline data for developing ecosystem services based landscape management plans.

Oak, Himalaya, ecosystem services, livelihoods

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

58 - Managing forests for Biodiversity and Resilience

KG I - 1010 (Uni Freiburg)

IUFRO17-1953 **Functional diversity in temperate managed forest of Mexico: a new approach to assess the impact of harvest intensity.**

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Abstract: In temperate forests of Mexico the main goal of harvest is to promote both single species even-aged and uneven-aged mixed forests. The impact of these systems on the biodiversity has been focused on evaluating plant and animal richness, however, the impacts on functions and processes as defined by functional diversity has not been addressed. The objective of this study was to define understory functional richness patterns in a conifer forest as a response of different harvest intensities, and years after its application. A 6.7 acres total sample surface was distributed in oaxacana pine stands located in north of Oaxaca state, Mexico, treated with the seed-tree regeneration method in 1998 and 2011, with selection method in 1998, thinned stand in 2011, and untreated stands. The understory vascular plants (herbs and shrubs) richness was identified registering plant height, frequency and dominance, we also revised in the literature the functional attributes related to biomass accumulation, carbon sequestration, foliage decomposition rates, evapotranspiration, dispersion, and disturbances response. Functional diversity patterns did not show a specific trend related to the harvest intensities, and years of application, however, the best qualification for functional diversity was found for the more recent and light harvest intensities.

Functional diversity, Pinus oaxacana, understory

KG I - 1010 (Uni Freiburg)

IUFRO17-2944 **Soil humidity, potential solar radiation and altitude affects boreal beetle assemblages in dead wood**

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Abstract: Topographic heterogeneity causes gradients in altitude, potential solar radiation and soil humidity on a range of scales. These gradients are important determinants for the distribution of many organisms but have been largely neglected in studies of species associated with dead wood. We evaluated the effects of topography-related gradients (altitude, potential solar radiation and soil humidity) and habitat characteristics (bark cover, ground contact and dead wood abundance) on saproxylic (wood-inhabiting) beetle assemblages. We sampled boreal saproxylic beetles hatching from 750 experimentally exposed spruce and birch logs in 10 landscapes. Saproxylic assemblage composition varied considerably in response to altitude, potential solar radiation and soil humidity. The response was evident in both forests and clear-cuts and for both birch and spruce logs. Species density and abundance responses differed among trophic groups. For birch logs, fungivore species density increased significantly with increased potential solar radiation. For spruce logs, altitude affected total species density and density of cambium consumers positively and abundance of fungivores negatively, suggesting a delay in succession due to slower decomposition at higher altitudes. Ground contact and bark cover of logs and the availability of deadwood also influenced the beetle assemblages. This shows that topography-related gradients affect assemblage composition of saproxylic beetles. To ensure the safeguarding of intact saproxylic assemblages it is important that the full range of deadwood habitats is conserved. Topographic heterogeneity also provide opportunities for landscape scale survival in response to rapid climate change. Some of the negative effects of climate change could be mitigated by allocating set asides and restoration efforts in areas where gradient in altitude, solar radiation and soil humidity are particularly well developed over short distances.

dead wood, biodiversity, beetles, topography

KG I - 1010 (Uni Freiburg)

IUFRO17-2806 **High resilience of tropical forest diversity and structure after shifting cultivation in the Philippines uplands**

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Abstract: Shifting cultivation is a widespread land-use in the tropics that is considered as a major source of forest degradation. In the Philippines, a country with rich biodiversity and high rates of species endemism, shifting cultivation, locally termed as kaingin, is a major land-use and has been for centuries. We investigated tree diversity and forest structure along a fallow gradient in an upland secondary forest regenerating after shifting cultivation in the Philippines. Species richness was significantly high in the oldest fallow sites, while Shannon's index, species evenness, stem number, basal area and leaf area index were high in the old-growth forest. A homogeneous species composition was found across the sites of older fallow age. Multivariate analysis reveals patch size as a strong predictor of tree diversity and forest structure recovery after shifting cultivation in the area. Our study suggests that regenerating tropical forests disturbed by shifting cultivation can exhibit high resilience and recover rapidly after five years. Although recovery of forest structure was not as rapid as tree diversity, our older fallow sites demonstrated comparable numbers of species as the old-growth forest. Novel and emerging ecosystems like secondary forests regenerating after shifting cultivation are of high conservation importance and can act as a refuge for dwindling tropical forest biodiversity.

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

84 - Promoting forest resilience, adaptive capacity, and ecosystem services through diverse forest

KG I - 1139 (Uni Freiburg)

IUFRO17-3016 **Silvicultural treatments to increase the provision of multiple ecosystem goods and services**

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Abstract: Increased concerns about impacts of a dominant emphasis on a single, narrow management goal (typically timber or fiber) led to investigations how even-aged monocultures can be converted to forests with structures and composition that provide for a wider array of ecosystem goods and services simultaneously. Results from such studies showed that treatment responses varied with initial conditions and spatial and temporal scales of measurement. The general trends were highly predictable, but most responses were spatially variable. Thus, accounting for initial conditions at neighborhood scales appeared to be critical for efficient conversion. Individual components of stand structure and composition responded differently to conversion treatments. Thus, achieving a wide range of ecosystem goods and services required the full suite of silvicultural treatments, from leave islands to variable density thinnings and creation of large gaps. The unique and sometime contradicting responses of the different components of structure and compositions suggest that foresters set priorities where and when specific ecosystem good and services are most desirable within a stand or landscape.

stand conversion, multiple ecosystem services

KG I - 1139 (Uni Freiburg)

IUFRO17-2378 **In search of robustness: modelling a portefolio of forest stand responses to different sylvicultural treatments under global change threats.**

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Abstract: Forests are faced with increasing social, economic and environmental pressure from a growing human population. As significant transformations of ecosystems are to be expected, many goods and services that humans derive from forests may no longer be maintained. With this presentation, we demonstrate that silviculture can be a positive and efficient tool to reduce the vulnerability of forests to global change if adaptation goals are explicitly integrated with other production and protection objectives. We propose a silvicultural approach based on the identification of a portfolio of silvicultural options in order to increase the adaptability of forest ecosystems to global change factors. This portfolio is made up of alternatives seeking to improve the resistance and resilience of the forest or to facilitate the transition toward a more adapted state in regards of different potential threats. An example from real stands in Quebec (Canada) threatened by climate change, the increase of drought intensity and frequency, the beech bark disease, the beech understory invasion and windthrow disturbances is presented. Monte-Carlo simulations from stand-level modeling is used to assess treatment alternatives from the point of view of their robustness in continuing to provide the expected ecosystem services under such pulse and push disturbances (sensu Millar & Stephenson 2015). These examples force us to revisit certain foundations of silviculture from a new angle and question ways silviculture has been done traditionally.

Adaptation, global change, modeling, silviculture

KG I - 1139 (Uni Freiburg)

IUFRO17-1544 **Enhanced carbon storage and co-benefits through management for structural complexity and old-growth characteristics in northern hardwood-conifer forests of North America**

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Abstract: Many have wondered if active management could be used to restore characteristics of High Conservation Value forests, such as temperate old-growth forests, to managed landscapes. As an example, forestry practices emphasizing stand structural complexity are of interest across the northern forest region of eastern North America because of their potential to enhance carbon storage and provide co-benefits. Our long-term research is evaluating silvicultural treatments promoting late-successional forest diversity, structure, and dynamics in northern hardwood-conifer forests. We test the hypothesis that aboveground biomass development (carbon storage) is greater in structural complexity enhancement (SCE) treatments when compared to conventional selection systems (single-tree and group) modified to retain elevated structure and emulate natural disturbances. Manipulations and controls were replicated across 2 ha. treatment units at two study areas in Vermont, USA. Data on aboveground biomass pools (live trees, standing dead, and downed wood) were collected pre- and post-harvest then again a decade later. We used the Forest Vegetation Simulator to project "no-treatment" baselines, allowing measured carbon responses to be normalized against differences in site characteristics affecting tree growth. Ten years after harvest, measured aboveground carbon in SCE units was 15.9% less than simulated no-harvest baselines, compared to 44.9% less in conventional treatments. Results from multivariate models indicate treatment as the strongest predictor of aboveground C storage followed by site-specific variables. Structural enhancement treatments have the potential to increase carbon storage in managed forests. They offer alternatives for adaptive management integrating carbon, climate mitigation, timber revenue, and late-successional biodiversity and habitat. Applications include old-growth and riparian restoration, carbon management, and low intensity commercial management.

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

84 - Promoting forest resilience, adaptive capacity, and ecosystem services through diverse forest

KG I - 1139 (Uni Freiburg)

IUFRO17-1180 **Managing young and mid seral secondary forests to increase their oldgrowthness in Chile**

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Abstract: Lowlands in south-central Chile lack old-growth forests and are dominated by secondary forests of different types and stages of development. Therefore, restoring old-growth forests or old-growth attributes in secondary forests becomes a need due to the diverse ecosystem services demanded by society from these forests. For this study we selected secondary forests in the stem exclusion and in the understory reinitiation stages of stand dynamics and an old-growth forest located in the Llancahue Experimental Forest (39 °50' S Lat) at 300-400 m a.s.l., in the heart of the Valdivian Temperate Rainforests. According to an "Old-Growth Index" developed for these forests, the one in the stem exclussion stage has a 5% of old-growthness and the one in the understory reinitiation stage a 35% of old-growthness. For each secondary forest we sampled six 1-ha plots, and we sampled three 1-ha plots in the old-growth forest. In three of the plots of each secondary forest then we conducted variable density thinnings to increase their heterogeneity and create other old-growth attributes. Sampling was conducted before harvesting and two seasons after harvesting, and it included trees, saplings, seedlings and understory, and mapping of all the trees. It also included blood sampling of four major bird species of these forests for fitness evaluation, and metagenomic analyses for microbial diversity and composition. We thinned the matrix to a 50% residual density by harvesting preferentially pioneer species to favor late-successional ones, and also created snags and coarse woody debris. In addition we created eight patches and equal number of reserves (or skips), four of 300 and four of 100 m2 in size. Here we report early results in regeneration, bird fitness, diversity and composition, and resulting vertical and horizontal structure following two seasons after thinnings. This innovative silvicultural approximation is financially profitable and creates greater complexity.

Variable Density Thinning, Complexity, Rainforests

KG I - 1139 (Uni Freiburg)

IUFRO17-1627 **Growth response on drought of European mixed-species stands compared with monocultures**

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Abstract: Mixed stands are on the advance as they can provide many ecological and social ecosystem functions and services better than mono-specific stands, and in addition they can be more productive and economic. However, climate change raises the question how mixed-species stands will respond to increasing drought, in comparison with monocultures. In the presentation drought responses will be traced from the stand to the tree level, and along a gradient from low to ample water availability.
First, based on the KROOF rainfall exclusion experiment in South Germany will be shown, how drought modifies the growth partitioning among the trees of different hierarchical status in mixed and mono-specific stands.
Second, long-term experiments are used for showing how reduction of stand density can modify drought effects on growth in mixed compared to mono-specific stands.
Third, a study along a gradient of water availability will reveal how drought effects are modified by actual site conditions.
The discussion addresses why drought stress is mitigated by tree species mixture. Finally, the consequences of the revealed growth reaction patterns for understanding, bio-monitoring, modelling, and silvicultural prescriptions will be emphasized.

resilience; resistance;productivity losses

KG I - 1139 (Uni Freiburg)

IUFRO17-2577 **The ecosystem service benefits of mixtures: Risk trade-offs and overcoming the implementation gap**

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Abstract: Mixed-species production stands are often suggested to support higher levels of biodiversity and provide a more balanced suite of ecosystem services than monoculture alternatives. Whereas there is evidence that mixtures in general provide positive outcomes relative to monocultures, it is less clear to what extent multiple benefits can be derived from specific mixture alternatives. To gain such insights requires evaluations of the biodiversity, ecosystem services, and additional forest management considerations provided by specific mixtures and monocultures within a region. Such studies may provide a basis for motivating the adoption of mixtures, or help explain the continued widespread use of monocultures. We have synthesized the available evidence regarding whether mixtures of Norway spruce (Picea abies) and birch (Betula spp.) are more likely to support a higher biodiversity than Norway spruce monocultures in southern Sweden. Our findings suggest positive outcomes from the adoption of this mixture for a distinct range of taxonomic groups, including vascular plants, lichens, saproxylic beetles, and birds. We subsequently contrasted the ecosystem services, biodiversity, and forest management considerations provided by mixtures of spruce and birch, or spruce and Scots pine (Pinus sylvestris) relative to Norway spruce monocultures. We identified positive outcomes from these mixtures including increased biodiversity, water quality, aesthetic and recreational values, as well as a likely reduced stand vulnerability to damages associated with pests, pathogens, and storms. However, some uncertainties and risks were projected to increase with the adoption of these mixture alternatives. We use these findings, and additional studies of post-disturbance planting decisions by Swedish forest owners to discuss the likely obstacles and opportunities for the increased implementation of production forest mixtures in Sweden.

adaptive capacity, mixture, biodiversity

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

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KG I - 1010 (Uni Freiburg)

IUFRO17-2207 **Impact of restoration and surrounding landscape structure on the risk of bark beetle outbreak in boreal coniferous forests**

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Abstract: Burning and gap-cutting are increasingly used in boreal forests to bring back components of natural forests that have been reduced by efficient silvicultural management and fire suppression. However, the use of these restoration methods to diversify forest structure and promote biodiversity may increase the risk of local outbreaks of bark beetles (Ips typographus, Tomicus piniperda) not only directly after the restoration, but also years after. Using pheromone trapping five years after restoration we assessed how the restoration treatments (burning and gap-cutting vs. control) and surrounding small-scale (10 m radius), stand-scale (100-200 m) and large-scale (2000 m) landscape composition affect bark beetle communities. The preliminary results show that burned stands do not support bark beetle populations sufficiently large to cause local outbreaks. By contrast in gap-cuts, elevated bark beetle densities are still maintained which may increase the risk of an outbreak, possibly depending on the landscape structure. The effects of landscape scales on bark beetle communities will be analyzed and presented.

Scolytinae, Fire, Gap-cutting, Ips typographus

KG I - 1010 (Uni Freiburg)

IUFRO17-3676 **Influence of forest tree species composition on bryophytic diversity in mixed and pure pine and oak stands**

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Abstract: The effects of mixed stands on biodiversity are increasingly being studied. Nevertheless, among the few studies dealing with epiphyte taxa, even fewer compare mixed stands with the pure stands of each species. We evaluated the diversity of tree-dwelling bryophyte communities in mixed and pure oak-pine stands (Quercus petraea (Matt.) Liebl., Pinus sylvestris L.) in French lowland forests. The main explanatory variables were the phorophyte species and the stand type (pure versus mixed) at tree level, the stand composition (pure oak, pure pine and mixed) at plot level. In addition, we investigated the role of the chemistry of the bryophyte substrates (soil, bark) and water supplies (stemflows, throughfalls), the basal area and interfering plant cover. Data were analyzed using Generalized Linear Models under Bayesian statistics. Richness and abundance of bryophytes were significantly and strongly higher on oak. Pine bryophyte richness at tree level was higher in mixed compared to pure stands, whereas mixed stands did not enhance oak bryophyte richness. Three species had a clearly higher probability to be found on pine, whereas seven species occurred clearly more frequently on oaks. Some species had a higher probability to be associated to pine in mixed stand than in pure stands, and one species was more prone to be found on pine within pure stands. As a conclusion, bryophyte biodiversity at the landscape level should benefit from the simultaneously presence of the three stand types: pure oak, pure pine and mixed. Exploratory models suggested strong effects of water supply chemistry which could explain the phorophyte species effect on bryophyte diversity. Basal area had a strong quadratic effect on plot epiphytic richness, and the best models for bryophyte diversity per tree always promoted the basal area effect in addition to (or interaction with) the main species and composition effects.

Forest biodiversity; bryophyte; mixed stands

KG I - 1010 (Uni Freiburg)

IUFRO17-2396 **Influence of stand age and forest type on spider taxonomic and functional diversity in plantation forests**

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Abstract: An increasing proportion of the world's forests are plantations and there is a growing reliance on these forests to deliver multiple ecosystem services. In order to design effective multifunctional forest management units, a better understanding of stand age influence on ecosystem services across multiple forest types is required.

Within plantations, spiders, as generalist predators, are vital in controlling pest species but also are an important food source for other organisms. Despite this, our understanding of the impact of commercial plantation management on spider functional and taxonomic diversity in common commercial plantation types across the UK is limited.

This project compared spider species diversity, functional diversity and functional redundancy in Sitka spruce and Scots pine plantation forests across four different stages of a forest harvesting cycle and semi-natural Oak woodland across two stages, with four replicates of each plantation type*age class combination. Sites were located across the UK in clusters matched for similar site history, elevation and soil conditions. Spiders were sampled continuously from May-September in 2016 using pitfall traps.

Spider community composition and functional diversity were affected by stand age and forest type. The results are discussed in the context of forest management and spider community resilience in commercial plantations.

spider, forest, functional diversity, resilience

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

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KG I - 1010 (Uni Freiburg)

IUFRO17-3138 **Biodiversity resilience in the wake of variable retention harvest in the Canadian mixedwood**

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Abstract: Since 1999 the EMEND experiment located in NW Alberta, Canada has explored the use of variable retention forestry in managing the boreal mixedwood forest for resilience of biodiversity following forest harvest. Data about epigaeic beetles and spiders, saproxylic beetles and boreal songbirds reveal that retention of even 10-20% of pre-harvest volume leads to faster recovery of biodiversity toward dynamic targets defined by unharvested control stands than happens subsequent to clear-cuts. Although faunal recovery is rapid in deciduous-dominated stands, it is significantly slower in conifer dominated stands and it is unlikely that biodiversity targets can be managed by distributed in block retention on its own. Distributed and aggregated retention appears to serve different functions in promoting biodiversity recovery but both tools can be applied in concert to help forest managers better meet the biodiversity targets that are commonly advocated under the Canadian approach to extensive forest management.

KG I - 1010 (Uni Freiburg)

IUFRO17-3146 **Drivers of ground-dwelling arthropod diversity in small and isolated semi-natural woodlands**

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Abstract: European forests have been subject to deforestation and fragmentation driven by the expansion of agricultural and urban areas. Selection of potential sites for woodland conservation is a key priority and in countries with significantly reduced woodland cover small and isolated patches have the potential to support forest-associated species. Spiders and Carabid beetles were sampled in oak (Quercus robur L., Quercus petraea (Matt.) Liebl.) and ash (Fraxinus excelsior L.) dominated semi-natural woodlands in Ireland using pitfall traps and potential environmental drivers influencing invertebrate diversity at stand and landscape scales were measured. Woodland type was a key driver of arthropod diversity with different assemblages and forest-associated species supported. Contrasting species richness patterns were seen, with spider richness greater in oak and beetle richness greater in ash. Cover of lower vegetation layers influenced spider diversity whereas litter depth was important for beetles. Landscape scale variables were less important, suggesting that smaller woodland patches have conservation value in an Irish context. Woodland conservation measures should seek to enhance or maintain arthropod diversity by targeting a range of woodland types and stands of different structural diversity. In addition, smaller patches, particularly those in highly modified agricultural landscapes, should not be overlooked.

woodland; biodiversity; management; spider; beetle

KG I - 1010 (Uni Freiburg)

IUFRO17-2367 **Tree diversity in plantation forests: evidence for the "portfolio effect" in a large-scale diversity experiment**

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Abstract: A central question in ecology is the extent to which biological diversity mediates ecosystem function. Diverse communities are thought to be more resilient due to complementary dynamics among species, referred to as the "portfolio effect". The global area of plantation forest is expanding and recent debate has focused on the impact of tree diversity on ecosystem function. We established a large-scale diversity experiment at the Smithsonian Environmental Research Center, Maryland, US. The "BiodiversiTREE" experiment manipulates tree species richness (1, 4, and 12 species from a pool of 16 native species) on a landscape scale (> 12 ha, ~20,000 trees in 75 35x35m plots) and forms part of the TreeDivNet global network of tree diversity experiments. We assessed growth and survival of trees, insect defoliation, and deer browsing. Survival in monoculture plots was highly species dependent, ranging from 98% for sycamore Platanus occidentalis to 38% for bitternut hickory Carya tomentosa. Variability in plot level survival declined with increasing diversity; diverse (12 species) plots ranged from 91% to 66% survival after three years. While diversity had little effect on plot level insect defoliation, some species exhibited less deer browsing in polycultures relative to monocultures. Overall, species rich mixtures were more resilient to biotic and abiotic stressors, evidence for the "portfolio effect" in diverse plantation forests.

ecosystem function, resilience, herbivory

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

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KG I - 1139 (Uni Freiburg)

IUFRO17-1202 **Ecological stability of mixed-species forests**

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Abstract: Forests are likely to face novel disturbance regimes as a result of global change and there is concern that the capacity of forest ecosystems to with-stand, recover from, or adapt to these novel disturbance regimes may decline. Creation and maintenance of species-diverse forests is seen as an important option to adapt forests to uncertain future disturbances. However, it is not known whether benefits of mixed-species forests consist mainly of risk spreading among tree species that have different susceptibility to various stressors and disturbance agents or whether they also have emergent properties resulting from interactions among species, which increase the resistance and resilience of participating species. Here we review the evidence for the effects of tree diversity on the resistance and resilience of forests in relation to a number of abiotic (drought, wind, fire) and biotic (insect herbivores, pathogens) stress and disturbance factors. For the abiotic disturbances, damage to susceptible species may be reduced, when they are mixed with more resistant species. However, storm, fire, or drought damage to individual species may not be reduced in mixtures when compared to monocultures. There is more evidence for beneficial diversity effects for biotic disturbance agents. Mixing tree species reduces the impact of insect herbivores on individual susceptible tree species in the majority of cases where the community is dominated by specialist herbivores. In most cases, tree species diversity dilutes the impact of disturbance agents and owing to different susceptibility of species to specific disturbances insures against a complete damage or loss. However, there is little evidence for true, positive diversity effects, where diversity leads to an increase in the resistance and resilience of component species in mixed-species communities. Possible benefits of mixtures depend largely on the attributes of the species in mixture in relation to the specific disturbances.

ecological stability, mixed forests, disturbance

KG I - 1139 (Uni Freiburg)

IUFRO17-3038 **The role of tree diversity for ecosystem resilience and services**

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Abstract: Land use change, climate change, or air-borne eutrophication, as well as forest management have considerable impacts on the biological diversity of forest ecosystems. Understanding and forecasting the consequences of these changes in biodiversity on ecological functions, services and resilience is certainly one of the major challenges for ecological research.
I report on results from a large-scale, pan European project (www.fundiveurope.eu) that investigated the relationship between tree diversity and ecosystem functioning adopting three complementary approaches: (i) tree diversity experiments, (ii) comparative plots in mature stands of six major European forest types, and (iii) data from National Forest Inventories from several European countries. A large variety of ecosystem characteristics and processes have been measured, including resistance and resilience towards climatic fluctuations or herbivory.
The study suggests a positive relationship between tree diversity and functions related to productivity, associated biodiversity, and soil parameters. However, no and even negative effects were also documented for other ecosystem processes, and effects of species identity were usually larger than those of diversity. Increasing tree diversity usually results in lower fluctuations of ecosystem processes and higher resistance against herbivores.
The question then arises whether we can design mixed species forest stands that capitalize on the different diversity effects to enhance and stabilize the delivery of multiple ecosystem services. So, can we use the diversity of trees as a tool to manage future forests? This implies consideration of knowledge at very different levels, ranging from species functional traits, interspecific mixing effects, but also trade-offs between different ecosystem services or stand versus landscape perspectives.

tree diversity, ecosystem function, FunDivEUROPE

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

23 - Tree biodiversity at the genetic level: vital to confront environmental and livelihood challenges

Room "Colmar" (Novotel Freiburg)

IUFRO17-2700 **Conservation and sustainable use of food tree species in Burkina Faso: a special focus on the priority species Parkia biglobosa**

Vinceti, B.* (1); Gaisberger, H. (1); Kindt, R. (2); Lompo, D. (3); Konrad, H. (4); Geburek, T. (4); Duminil, J. (1); Ouedraogo, M. (3); Pehou, C. (5); Djoudi, H. (6); Elias, M. (1)

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Abstract: The paper focuses on an example of implementation of research on conservation and sustainable use of forest tree genetic diversity that supports the implementation of the Global Plan of Action, derived from the State of the World's Forest Genetic Resources.
The multidisciplinary research conducted in Burkina Faso led to the development a priority setting tool for the definition of conservation priorities at the country level for a set of 16 food tree species, examining the spatial distribution of threats to these. In addition, the project carried out a first range-wide characterization of the genetic diversity of a priority food tree species, Parkia biglobosa, under threat in some parts of Burkina Faso and subject to growing exploitation. The combination of a threat map with a genetic map enables understanding what species traits are likely to be lost with the disappearance of some tree populations. At the landscape scale, in representative sites, the research examined geneflow in P. biglobosa to assess if current local management practices are contributing to the isolation of individual trees and a progressive erosion of intraspecific diversity. Finally, at the local level, land and tree tenure and its potential influence on Parkia biglobosa management and conservation, were examined.

genetic resources; Parkia biglobosa; conservation

Room "Colmar" (Novotel Freiburg)

IUFRO17-3759 **Tools for mapping threats and planning conservation of forest tree genetic resources**

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Abstract: The Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources, adopted by the FAO Conference in 2013, identifies actions needed at multiple geographic levels to enhance the contribution of genetic resources of forest trees and other woody species in addressing global challenges and opportunities. The Global Plan of Action is a call for policymakers, researchers, managers, practitioners and others who are concerned with tree genetic resources to work towards preventing further erosion of genetic diversity and enhancing the use of this diversity. Understanding and mapping threats to populations of tree species provides valuable information for developing plans and strategies for conserving their genetic resources. We provide examples of the tools that we have developed and applied in Sub-Saharan Africa, Central Asia and Latin America to assess threats to populations of tree species. In each case we combined patterns of genetic diversity with mapped threats across the distribution of tree species, and tested our conclusions with local expert opinion.

forest genetic resources, genetic diversity

Room "Colmar" (Novotel Freiburg)

IUFRO17-3813 **Development and implementation the in situ conservation strategy for the conservation and sustainable use of forest genetic resources in Europe**

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Abstract: European countries have are committed to the global plan of action for the conservation, sustainable use and development of forest genetic resources (GPA-FGR). For its implementation, countries collaborate mainly through the European Forest Genetic Resources Programme (EUFORGEN). EUFORGEN is an international cooperation programme promoting the conservation and sustainable use of forest genetic resources in Europe as an integral part of sustainable forest management.
EUFORGEN provides a unique platform to exchange information and promote a science-policy-practice dialogue, contributing to the development of conservation strategies and the identification of priorities and responses to policy gaps. More than 30 European countries have contributed to EUFORGEN and its work, to date.

The European Region is particularly advanced in the "Development and implementation regional in situ conservation strategies and promote ecoregional networking and collaboration" (Strategic Priority 11): In 2015 EUFORGEN member countries released the "Pan-European strategy for genetic conservation of forest trees" and started its implementation. The Oral Presentation will introduce the strategy and the means to verify its implementation.

forest genetic resources, GPA-FGR, Europe, in situ

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

23 - Tree biodiversity at the genetic level: vital to confront environmental and livelihood challenges

Room "Colmar" (Novotel Freiburg)

IUFRO17-724 **Potential population genetic consequences of habitat fragmentation for Central European forests**

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Abstract: Gene flow and random genetic drift are the major processes governing the genetic structure of fragmented or spatially isolated populations of strongly reduced size. Levels of both may be assessed using standard population genetic theory, but in praxis underlying assumptions are often violated. Thus, computer simulations are a promising approach to forecast the genetics of fragmented populations. We (i) aimed to identify intrinsic (i.e. species) and extrinsic (i.e. environmental) properties of populations which potentially affect the genetics of Central European tree species and associated understorey species, and (ii) developed a simulation tool accounting for the genetic composition, demography, ecology, and spatial arrangement of individuals encountered for any real (or virtual) population.

We surveyed the literature for data on levels of effective gene flow and on patterns of population genetic differentiation and quantified effects of intrinsic and extrinsic properties on the genetics of populations using GLMs and ANOVAs. The simulation tool, developed as R script, represents the whole life cycle of individuals, i.e. combines modules for mating; seed dispersal; establishment, growth and decease. It is parameterized using spatial coordinates, genotype, ploidy, age, mating system, male and fertility of individuals; complemented by pollen and diaspore dispersal probabilities, as well as age- and ecology-dependent survival rates.

Mode of inheritance of markers, pollination type and spatial extension of the study area were key parameters governing the genetics of tree populations. Population genetic data in combination with estimates of actual levels of gene flow on understorey species are too scarce yet to draw such conclusions. Nevertheless, basic data on the biology are available for most species which can be used for model parameterization. Modular design thus allows to adapt or extent our simulation tool making it suitable for both tree and understorey species.

conservation, gene flow, population genetics

Room "Colmar" (Novotel Freiburg)

IUFRO17-2934 **Genetic diversity structure of populus nigra populations in a major river system in Turkey. What is the role of human impact?**

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Abstract: Populus nigra is one of the most economically and ecologically important forest trees in Turkey, well known for its rapid growth, good ability to vegetative propagation and the extreme uses of its wood. Due to overexploitation, loss of natural distribution area and extreme hybridization and introgression, Populus nigra is one of the most threatened tree species in Turkey and Europe. Using seventeen nuclear SSR loci, the genetic structure of European black poplar populations along the largest river of Turkey was analyzed. All tested loci were highly polymorphic, displaying 4 to 12 alleles per locus. Observed heterozygosity (overall Ho = 0.79) has been higher than the expected (overall He = 0.54) in each population. Although whole river system is sampled from upstream, middle and downstream systematically, low level of genetic differentiation among three locations (FST= 0, 01) and excess of heterozygotes for each location were found. Human mediated dispersal, phenotypic selection, high level of gene flow and extensive circulations of clonal materials may cause to those situations. The genetic data obtained from this study could provide basis for efficient conservation and restoration of species natural populations in its natural habitat as well as having sustainable breeding and poplar plantations in the future.

Key words: Populus, clonal, loci, allele, nuclear

Room "Colmar" (Novotel Freiburg)

IUFRO17-3191 **Involving stakeholders to develop a strategy for improved broadleaved trees: experiences from Britain and Ireland**

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Abstract: We report on a stakeholder consultation undertaken to develop a new strategy for improved broadleaved trees in Britain and Ireland for 2013-2025. The overarching aim of the strategy was to promote tree improvement practices that would lead to increases in the productivity and health of woodlands. Stakeholders represented a range of public- and private-sector organisations, and individuals from across the sector with an interest in British and Irish trees and woodlands, not only for high-quality timber, but also for wider social and environmental benefits. The iterative consultation involved a two-phase process. During the first phase, stakeholders completed an online survey which captured current awareness and actions with respect to improved planting material, and aspirations for the future strategy. The survey revealed a wide range of interpretations of 'local' and assessments of the importance of 'local adaption', generally and in the light of emerging tree diseases and predicted climate change. Respondents generally expressed good understanding of discussions about provenance, seed source and choice of planting material, while expressing a lack of understanding about genetic diversity or genetics as a scientific subject. Relatively few non-governmental respondents engaged in planting had a policy on sourcing material and not all nurseries were explicit about the origin of planting material. Respondent suggested priorities for the new broadleaved strategy were fed into phase two, where they were reviewed and revised in workshops in each of Ireland, Scotland, Wales and England. Successive workshops built upon the revisions of the previous workshop in an iterative process that enabled identification of generally-agreed priorities while noting national differences.

improved trees,stakeholders,Ireland,UK,broadleaves

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

23 - Tree biodiversity at the genetic level: vital to confront environmental and livelihood challenges

Room "Colmar" (Novotel Freiburg)

IUFRO17-2954 **Characterizations of Genetic Diversity and Population Structure of Salix alba Population in the Longest River Ecosystem in Middle Anatolia**

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Abstract: The genus Salix L. is represented with more than 500 species in the world and 28 of species are found naturally in Turkey. The species of the genus have been widely used for bioenergy and phytoremediation. Salix alba like many other willow species is with great renewable energy potential and important component of an healthy riparian ecosystem as an indicator species in major river ecosystems in Turkey. With this study, it was aimed to provide information for efficient conservation, management and utilization of genetic resources of S. alba under increasing habitat deterioration and fragmentations. To meet this objective, one populations of Salix alba from upper, middle and the lower portion a major Middle Anatolia river ecosystem (Kizilirmak river) in Turkey were sampled and screened with 20 nuclear SSR markers. Average number of alles per polymorphic locus was 11.65 with the range of 3 to 24. Average observed heterozygosity estimated as 0.65 per locus. Although genetic differentiation of populations (Fst: 0,03) was found to be low, those three population maintain desired genetic diversity. Constructed dendrogram based on genetic distance, the lower part of the river system was genetically more distance to the remaining populations. The core population regarding genetic diversity and differentiation seems to be located middle part of the river system.

Genetic diversity, SSR,Population, Salix

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

47 - Open Session

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-606 **Opportunities and Challenges for theProtection and Ecological Functions Promotion of Natural Forests in China**

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Abstract: Excessive logging in China is the major cause of poor forestquality, degradedecosystem functions, and near exhaustion of harvestable resources ofthe country's natural forests. As the demand for timber continues to increase rapidly, China will experience a severe imbalance between timber supply and demand. In the long run, timber imports alone cannot meet increasing domestic demands and natural forests remain the primary source of wood products. Efficient cultivation and sustainable development of natural forests is essential toensuring long-term timber supply in China. Both researchand management practices pertaining to ecosystem construction and the sustainable operation and management of natural forestsin Chinahave been in place forless thantwo decades. Thus many issues concerning management practices and operationstechnology remain,including ineffective overall spatial zoning, rough operation and management of timber forests, and financial difficulties inforested areas. All of these issues have prevented natural forests from realizing both their ecological functions and timber resource potential. An overall extended moratorium on logging in the country's natural forests is a suggested method for the gradual recovery of the structure and functions of these forests. A moratorium on timber harvesting would offer a valuable opportunity for natural forests to recover from decades of excessive logging, as well as an exciting chance to develop sustainable operationalpractices, ecological functions promotionand relevant technologies. This paper analyzes changes in domestic natural forests and timber supply and demand in China.Problems related to the sustainable operation of natural forests, especially those requiring immediate attention,are identified,and strategies for the sustainable management of natural forests during a harvesting moratorium are suggested.

Protection Ecological Functions Natural Forest

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-407 **Assessment of conserved trees in selected recreation centers in Ibadan, Oyo State, Nigeria**

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Abstract: This study assessed the status of conserved trees species in five selected recreation centers in the urban area of Ibadan. These centers include; Agodi Gardens (AG), Ibadan Recreation Club (IRC), National Museum of Unity (NMU), Ibadan Golf Club (IGC) and Ibadan Polo Club (IPC). The selected Recreation Centers were purposively selected due to the presence of tree species and complete enumeration of the trees was done. AG had in total 540 trees, 46 tree species and 25 families. IRC had the total number of 148 trees, 32 trees species and 22 families. NMU had the total number of 770 trees, 23 tree species and 17 families. IPC had the total number of 97 trees, 20 tree species and 15 families. IGC had the total number of 915 trees, 31 tree species and 9 families. The five selected recreation centers are ex-situ urban centers/parks that still maintain and conserve various tree species for enjoyment of the tourist during their holiday and visitation on daily basis. However, the political will on the garden, museum and clubs should be such that it will remain a heritage that must be preserved for generation yet unborn.

Environment, resorts, tree species, conservation

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3025 **Thinning enhances the resistance and resilience of forest ecosystems to drought**

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Abstract: The predicted increasing impacts of global change call for practical strategies to minimize the vulnerability of forest ecosystems to drought. Tree population density, a metric of tree abundance in a given area, is a primary driver of competitive intensity among trees, which influences tree growth and mortality. Manipulating tree population density may be a mechanism for moderating drought-induced stress and growth reductions, although the relationship between tree population density and tree drought vulnerability remains poorly quantified, especially across climatic gradients. We examined three long-term forest ecosystem experiments in two widely-distributed North American pine species, Pinus ponderosa and Pinus resinosa, to better elucidate the relationship between tree population density, growth, and drought. We investigated how tree population density influenced the resistance and resilience of stand-level growth during and after documented drought events. Our results show that trees growing at lower densities were less vulnerable to drought. This result was apparent in all three forest ecosystems, and was consistent across species, stand age, aridity range, and drought intensity. Managing forest ecosystems at low tree population density represents a promising adaptive strategy for reducing the negative impacts of drought on forests in coming decades.

Climate change adaptation, Tree population density

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

47 - Open Session

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3197 **Land abandonment and spontaneous rewilding: effects of forest recovery**

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Abstract: Many world countries are currently facing forest transitions where a net gain of forest area is observed. As a result of land use abandonment and in the absence of artificial planting, spontaneous forests might develop through secondary ecological succession. Current research on reforestation uses multiple time frames, spatial scales, and diverse data sources. Hence, integration of the diversity of research on this topic is a challenge. We prepared a worldwide database on spontaneous reforestation occurring after the cessation of agricultural and farming activities by systematically searching the bibliography through a combination of keywords and by assessing studies against a set of specific inclusion criteria. Studies were classified according to a set of qualitative (e.g., country, imagery type, tree species, exotic species occurrence) and quantitative data (e.g., area, time frame, rate of reforestation). Spatial information was used to map the studies and to highlight areas with higher research effort. Furthermore, a comparison between total spontaneous reforestation and net reforestation was made. Focusing on dataset type (e.g., cadastral surveys, aerial photographs, satellite images), and spatial and temporal scales of analysis, information is used to shed light on reforestation research and to suggest future research needs. Furthermore, this research enables to better understand the possible consequences of spontaneous reforestation on biodiversity and ecosystem services.

global change, forest expansion, land abandonment

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-922 **Clonal propagation and cryopreservation of germplasm for coping with climate change in Japanese larch (Larix kaempferi)**

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(1) National Institute of Forest Science, Forest Biotechnology Division, Suwon, Korea, Republic of (South Korea); (2) National Institute of Forest Science, Suwon, Korea, Republic of (South Korea); (3) Natioanal Institute of Forest Science, Suwon, Korea, Republic of (South Korea)

Abstract: Most of the embryogenic tissue (ET) were induced from late cleavage polyembryony to the early proembryo stages of zygotic embryo. The advanced treatments for somatic embryo (SE) production were invented that consisted of 60 uM abscisic acid (ABA), 0.15 M maltose, 7.5% Polyethylen glycol (PEG) MW8,000 and 0.8% gellan gum. The germination rates were high (68-71%) when germinated with 0.2 or 0.3% gellan gum.
The survival rate of somatic plantlets was sharply increased to 95% or more when using Peat-plug (ihort, USA) during acclimatization. A cryopreservation method was developed for long-term storage with mature SE instead of ET in Japanese larch. In the effect of different dehydration temperature and duration for the re-initiation ET, the
highest frequency was shown when SEs were dehydrated at 25 C for 2 (45.5%) or 1 day (43.3%), respectively. In addition, low temperatures [4 C, 2 days (44.2%) or 3 days (43.5%)] were marked higher ET initiation. For comparison of different relative humidity on
re-induction frequency of ET, the best (43.5%) was obtained from SEs pre-dried at (NH4)2SO4 (RH 79%). However the lowest rate (19.6%) was observed in distilled water (RH 100%). In comparison of the various storage temperatures and duration of the dried SEs, the highest frequency (66.9%) of re-initiation was obtained when SEs were
cryopreserved for 1 day. However, the frequency was gradually decreased as the time length of storage increased regardless of types of storage. None of ET was re-induced when stored at 4 C for 1, 2 and 84 days.

Cryopreservation, Somatic embryo, Peat-plug

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1159 **Sub-national Forest Transitions: A matter of scale and regional drivers?**

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Abstract: Knowledge of forest cover development (de-/reforestation) and its drivers is a precondition for designing effective land use planning and policies to halt deforestation not only national, but especially at sub-/ or regional-scale. The forest transition hypothesis concept has been used to examine the development of forest cover decline and re-expansion. Depending on the scale and drivers considered, the concept supports the identification of policy and forest management options that can lead to more productive and sustainable forest landscapes. However, whether the approach also produces useful results at sub-national level has not received much attention to date.
The presented study analyses the forest cover development on sub-national scale for the case of Philippines to assess the existence of a sub-national pattern of forest transition patterns. Sub-national administrative units up to municipality-level were taken into account and analysed according to biophysical conditions (e.g. topography, soil types), demographic (e.g. population density and growth) and other (socio-)economic drivers. The study investigates whether a pattern of forest cover development exists across scales and regions or whether different pathways of influencing drivers exist on different scales for the case of Philippines. Findings will be compared with similar assessments conducted for the case of Ecuador and Zambia, respectively.

Forest transition, Scale, Drivers, Tropics

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

47 - Open Session

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3630 **FSC certification - Long-term impact on conservation values in the landscape**

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Abstract: The forest certification standard contributes to shape the new forest landscape. In our study the objective was to investigate how the FSC-landscape will contribute to achieve long-term conservation of forest species. The study is based on two different methods, a literature review and computer simulations of a modelled landscape based on actual forest data. In the literature review we evaluate the ecological stringency of the certification standard in the light of relevant field studies. Is the certification, if properly applied, likely to achieve sustainable use of forest biodiversity? In the simulation study we focus on set-asides, which is one of the most important measures in the FSC-standard for conservation of biodiversity. We use data from a real landscape, dominated by FSC-certified forest owner. The data includes the present area and habitat configuration of set-asides . However, in order to evaluate the impact on connectivity, different scenarios are used in which the area of set asides varies. Based on the result we discuss the potential effects of the FSC standard on biodiversity in boreal and temperate forests of northern Europe and the relationships between measures of biodiversity and the parameters directly expressed in the standard.

certification,biodiversity,landscape configuration

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1832 **An isolated outpost of stone pine (Pinus cembra) and its genetic relationships**

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Abstract: While *Pinus cembra* grows in fairly large and continuous timberline forests in the Central Eastern Alps, there are several small and isolated populations on the edge of this range in Austria. This is interesting because the species' seeds are bird-dispersed, and the birds do not cover great distances for this purpose. This means that small populations can be 'trapped' on mountain tops in warming climates, once their nearest neighbours have disappeared. One such population of less than 100 individuals on the Austrian-Slovenian border was analysed for its degree of genetic variation, and the degree of relatedness to stands in the more continuous range of the species. Surprisingly, the population does not seems to suffer from genetic erosion: the number of chloroplast microsatelite variants is comparable to stands in the more continuous range (though there are fewer private alleles). The population does not stand out in a principle component analysis. In a similar way, nuclear microsatellites do not reveal very strong differentiation: while the population is recognisably different, it does not appear to be strikingly more differentiated than other investigated stands. Overall, a picture emerges where stands of this species are slightly more differentiated from each other than those of other forest conifers that typically grow at lower elevations, but but the geographical isolation of this particular stand does not seem to have led to very strong genetic isolation (yet). Possible explanations for these observations, like the very long generation times of the trees, will be discussed.

Pinus cembra, marginal population genetics

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3821 **Antioxidant variability in the seeds of the core and marginal populations of Lebanon cedar (Cedrus libani A. Rich.)**

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Abstract: The largest natural and northern distribution of Lebanon cedar is in Turkey, with narrow distributions areas in Lebanon and Syria. The present distribution is restricted mainly to the Taurus Mountains in Southern Turkey, where good adapted and optimal populations are found, especially in the Elmali province in Antalya. Moreover, there are three populations in the Northern Turkey (provenances Erbaa- Çatalan and Niksar-Akinci) and one population in Afyon-Emirdag. These disjunct populations are marginal and clear isolated. This species is a significant and salient tree species in historical, cultural, aesthetic, and economic terms.
As a resistant species against drought and frost, Cedar has an essential meaning for Turkey and is the second species for afforestation. Currently, there are 23 seed stands and 19 populations as gene conservation units selected. Assessment of genetic diversity in isolated stands is of great importance for the conservation and improvement programs. In this study, we focus on the core and the peripheral populations because of their importance for gene conservation. Under the effect of global climate change, they may possess genotypes for future adaptive potential. The aim of this study was to determine the alfa-amilaz and the antioxidant variability [(Catalase (CATs), Superoxide dismutase SODs, Ascorbate Peroxidase (APX) and glutathione peroxidase (GPx)] in the seeds of the five optimal (Kahramanmaras -Andirin / Elmadagi, Adana - Pozanti / Pozanti, Mersin - Anamur / Abonoz-2, Antalya - Finike / Aykiri çay and Antalya - Kas / Kara çay) and two marginal populations (Amasya -Tokat / Niksar / Çatalan and Eskisehir - Afyon / Suldandagi) in Turkey.

stress, core population, seed vitality, cedar

Theme 4: Biodiversity, Ecosystem Services and Biological Invasions

96 - The role of plant tissue culture technology in biodiversity conservation

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-236 **Investigation of genetic resource conservation of various types of seeds using cryopreservation technique**

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Abstract: Biota orientalis, Acer monspessulanum and Pistacia vera are endangered forest species in Iran. To evaluate the possibility of long-term preservation of B. orientalis, A. monspessulanum and P. vera seeds three pre-cryopreservation methods including plant vitrification solution2 (PVS2), desiccation, and 30% glycerol in addition to control were applied. Cryopreservation techniques are used to preserve plant seeds, organs and cells at -196 ºC in Liquid Nitrogen. The treated seeds were kept in liquid nitrogen (LN) for periods of 1 month then were removed, germination percentages and establishment were evaluated. The results showed that in B. orientalis and P. vera there were significant differences among cryopreservation pre-treatments and control and in A. monspessulanum there were no significant differences and seeds of this species are highly tolerant to cryopreservation conditions. Also the most important achievements in these seeds are able to tolerate cryopreservation conditions and they cloud be preserved under cryopreservation conditions for a long period of time. Moreover, with the use of this technology, the seeds of this endangered species can be collected from different habitats and preserved for a long period. To save a species from becoming extinct, the seeds can be recovered and replanted in the disintegrated habitats with the aim of afforestation.

B. orientalis, A. monspessulanum, P. vera

Theme 5: Forests, Soil and Water Interactions

18 - Forest floor matters - The pivotal role of a forest compartment in danger of extinction

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2978 **Forest floor dynamics in the light of the new German humus-form classification**

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Abstract: The humus form with its three main groups Mull, Moder and Mor is a central field-assesseable criterion for the ecochemical state of forest sites. All changes in the soil environment such as climate, canopy density, litter quality, nitrogen deposition, or liming mostly trigger an obvious dynamic in thickness, layering, and internal structure of the forest floor. However, when using traditional forest-floor classification systems these obvious changes are often poorly reflected. Recently a working group of the German soil-science association (DBG) published an adapted classification framework. The two major innovations are (1) a stronger morphological subdivision of the O-type layer consisting of amorphous humic substances and (2) the introduction of non-equilibrium disturbed humus forms. Based on field assessment and microscopic views on resin-impregnated polished slabs we will discuss the long-term effect of liming on the humus form. The comparison of previous and new humus form categorization reveals to what extent the new classification can increase the information depth when used in environmental monitoring or forest-site survey.

O horizon, resin impregnation, liming, moder

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1659 **Phosphorus mineralization in forest floors differing in litter composition**

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Abstract: The foliar phosphorus (P) nutrition of several tree species is decreasing in Europe over time. Probably, several factors contribute to this deterioration, but the reasons are not fully understood. Yet, it is known that the forest floor plays an important role for the P nutrition of trees. Forest floor chemistry and nutrient turnover is affected by site and soil properties, but also by the tree species grown at a site.

We hypothesize that (1) the variance in forest floor P mineralization at one site with plots differing in tree species composition is similar to the variance at different sites consisting of the same tree species; (2) cumulative P mineralization depends on the nutrient stoichiometry of the forest floor.

At one site in the north-east of Germany with plots consisting of three different tree species mixtures (pine-beech, Douglas fir-beech, Douglas fir) and at 14 beech forest sites in middle and northern Germany the forest floor was sampled in spring. The cumulative P mineralization was determined by percolation of disturbed forest floor columns during 84 days of incubation at 8 °C. Microbial biomass P and carbon (C) were measured once by the chloroform-fumigation-extraction method at the beginning of the experiment.

(1) The variance in cumulative P mineralization among the forest floors differing in litter composition (pine-beech, Douglas fir-beech, Douglas fir) was similar to the variance among the pure beech sites. The P mineralization was highest in the Douglas fir-beech forest floors, followed by the pure Douglas fir forest floors and lowest in the pine-beech forest floors. (2) The cumulative P mineralization in the Of horizon was strongly correlated with both the C:P and the N:P ratio of the forest floor on pure beech sites, but not on the other site with plots differing in tree species composition. The microbial C:P ratio of distinctive forest floor horizons was very similar for all the sites, independent of the tree species.

microbial P, beech, Douglas fir, pine, Germany

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-2525 **Leaf litter decomposition in translocation experiments across altitudinal gradients in Costa Rica and longitudinal gradients in South Korea**

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Abstract: Understanding of the factors controlling litter decomposition is key to the description of carbon and nutrient cycles in forests, and how these processes are influenced by changing climate. Leaf litter translocation experiments have been carried out: 1) in four altitudinal bands in mature forest in protected areas in Costa Rica covering an altitudinal gradient with 11 oC - 25oC range of mean annual temperature, 2) in three longitudinal gradients in South Korea with 1,200mm - 1,850mm range of mean annual precipitation. In Costa Rica, 2,400 litter bags from two dominant species in each forest type, as well as two standard species, Acalypha communis and Stipa macrostachya, were placed on the forest floor and were collected over ten harvesting times across 540 days, and decay rates (KT) were calculated. In South Korea, 216 litter bags from two dominant species, Quercus acutissima and Q. salicina, were done following the above process. Overall remaining dry matter in Costa Rica (DM) varied between 38% in lowland wet (400-600m asl) and premontane (1000-1200m asl) rain forests and 65% in montane forest (2600-2800m asl). There were significant forest-species, time-species and forest-time-species interactions in DM. Both upland forest types had lower KT than the lowland and premontane forests, which did not differ from each other. The overall trend was for faster decomposition in species from montane and lower montane forests than in those from premontane and wet forests. We found an expected overall negative relationship of decomposition rates to altitude. Species effects on decomposition rates are complex and low KT in species from lowland and premontane forests suggests that if ecosystem process rates are higher in these forests than in lower montane and montane forests, these differences will be due to climate and not to species leaf traits. We are expecting that the longitudinal gradient study will support this suggestion.

decomposition litter bag precipitation temperature

Theme 5: Forests, Soil and Water Interactions

18 - Forest floor matters - The pivotal role of a forest compartment in danger of extinction

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-1359 **Interaction between forest floor and mineral soil: an approach to quantify bioturbation under different tree species**

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Abstract: Bioturbation is one of the driving processes for particulate transport in soils and thus influences soil structure and fertility, as well as the turnover of the forest floor and the incorportation of organic matter in the mineral soil. Nevertheless, it is difficult to quantify bioturbation directly. An indirect method is the application of tracers and the assessment of the vertical re-distribution after a certain time. The artificial radioactive isotope caesium-137 (^{137}Cs), which was spread over wide parts of Europe in 1986 after the Chernobyl disaster, was already used to assess soil erosion and bioturbation rates in other ecosystems, e.g. grasslands. In this study, we analysed the depth distribution of ^{137}Cs in the forest floor and mineral soil to test if European beech (*Fagus sylvatica*), Silver fir (*Abies alba*), and Norway spruce (*Picea abies*), affect bioturbation rates. The different species were compared among each other at three different forest sites, where we expect different bioturbation rates due to differences in pH and organic matter quality and where small and at least 30 years old groups of these tree species were available under old spruce due to underplanting and natural regeneration, respectively. Under each tree species, four soil cores were taken and divided into nine different layers resulting in a vertical depth profile. The soil samples were sieved (2 mm) and homogenized before the ^{137}Cs contents were measured with a high purity germanium detector. First results from an acidic site show that the method is suited for measuring the re-distribution and indicate that bioturbation still plays a minor role for all three tree species. The next step consists of applying a model including physical advective-dispersive transport, plant uptake, as well as local and non-local mixing. This allows a better comparison between tree species and sites as well as the identification of other potential factors influencing the re-distribution.

interaction between trees and soil, forest floor

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-4025 **Impact of Sessile Oak and Scots Pine on forest floor ecology of acid sandy soils in northern Saxony, Germany**

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Abstract: In particular on nutrient-poor soils, high proportions of organic matter (OM) and nutrient turnover are located in the forest floor. In the present account we investigated the impacts of *Quercus petraea* and *Pinus sylvestris* on nutrient fluxes, on chemical and biological properties of forest floor and topsoil in mature stands (oak ~140a; pine ~110a) on acid sandy soils. Tree nutrition and composition of the ground vegetation were investigated. An incubation experiment was conducted to test for responses of microbes to C, N, and P additions. Soil chemical and physical analyses of deep mineral soil revealed that investigated sites were comparable in terms of *a priori* nutrient status and soil texture.
In the oak stand, litterfall amounted to 3.4 t C*ha-1*a-1 which doubles that of the pine. In contrast, organic C stored in forest floor was half of that in the pine. The differences in the balance between in- and output of forest floor OM were not mirrored by the initial decomposition dynamics (1a-litterbag study), mainly due to the exclusion of earthworms. Differences in microbial biomass and chemistry were restricted to the upper part of the forest floor (OiOe1) and diminished in the deeper part. In microbial biomass was 2-3-fold higher in OiOe1 of the oak stand. These patterns were associated with higher pH, exchangeable Ca and DOC/N. Higher biomass and dynamics suggest higher rates of nutrient release which may increase nutrient availability for plants as indicated by differences in the composition of the ground vegetation. Observed dynamics in the responses of microbes to nutrient additions revealed differences in microbial limitation and community composition. Parallels existed between tree nutrition, N/P release during litter decomposition and the responses of microbes to nutrients. Altogether, the results underline the relevance of tree species impacts on forest floor and highlight the susceptibility of forest floor ecology.

soil microorganisms, nutrient dynamics, limitation

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-950 **High soil phosphorus concentration defines ground vegetation cover composition in subarctic forests**

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Abstract: We studied the relationship between soil nutrients and ground vegetation cover at subarctic forests in eastern Lapland, Finland. Part of our research sites were located on naturally phosphorus (P) rich soils and part on soils with P levels typical for the region. This enabled us to examine how high soil P affects site properties in northern latitude forests, which is a poorly known topic. We expected needle concentrations to vary with different soil P levels. Another hypothesis was that soil P concentration is connected to ground vegetation cover dynamics.

We took soil samples from each site and divided them into different horizons in order to study total element concentrations from different depths. Needle samples were also taken and their total element concentrations analyzed. Ground vegetation cover was analyzed by visual estimation. Contrary to our expectations, needle concentrations were similar between sites. The other hypothesis was, however, confirmed. Sites with high soil P had more herbs and grasses, both in number of species and in percentage of cover, than sites with normal soil P concentration.

This study will add knowledge about how soil properties can be estimated by ground vegetation cover as well as help in predicting how vegetation dynamics of subarctic forests may change in the future. Rising mean annual temperature can alter soil microbial activity and allow for increased release of nutrients. This can lead to drastic changes in vegetation composition by changing the dynamics of current species as well as possibly allow for invasive species to enter more easily.

ground vegetation, phosphorus, soil, climate

Theme 5: Forests, Soil and Water Interactions

18 - Forest floor matters - The pivotal role of a forest compartment in danger of extinction

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-3505 **Increase of C/N-Ratios in Forest Soils in Germany: Analysis and discussion of possible explanations**

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Abstract: The National Forest Soil Inventory (NFSI) is the only spatially representative assessment of the status of forest soils in Germany. After its first execution in the years 1987 - 1993, it was repeated on the same plots along a grid of 8km x 8km spread over large parts of the country between 2006 and 2008.

The repeated inventory revealed a significant increase of C/N-ratios in German forest soils, which was more pronounced in deeper layers than in the uppermost layer of the mineral soil and humus layers. The increase is associated with increasing carbon (C-) stocks as well as decreasing nitrogen (N-) stocks of the soil layers.

A multifactorial statistical model on climate and soil variables is employed to identify significant variables and possible soil processes leading to this development. Stronger nutrient uptake by trees, changed C and N input by fine root turnover and leaf litter, and more nitrogen losses by leaching and gaseous emission are potential explanations. The relative size of these fluxes is estimated and balanced in order to detect ongoing processes in the subsoil and their consequences for C and N storage in forest soils.

National Forest Soil Inventory, CN-ratio, nitrogen

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-973 **More than we ever thought - distribution and function of lithic histosols in the Calcareous Alps**

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Abstract: There is increasing evidence that thick forest floors overlying poorly weathered rocks and gravel ("lithic histosols" or "Tangel") are more widespread in the Northern Calcareous Alps than previously thought. As ecosystem services such as water retention, carbon storage and protection against erosion and snow movements crucially depend on intact forest floors more information about their distribution in the landscape is needed.
In Winalpecobase, a systematic-stratified sample of 1,505 joint observations of soils and vegetation in the Bavarian Alps, 67 profiles were classified as histosols and an additional 68 profiles were assigned the humus form "Tangel" - thus 9% of all profiles had features of lithic histosols, 64% of them with >20cm, 40% >30cm and 26% >40cm forest floor thickness. Their proportion was even higher on hard limestone (24%) and dolomite (13%), which is the most frequent bedrock in the region. As expected lithic histosols are most frequent under subalpine Pinus mugo krummholz and Picea abies forests, but occur regularly also under mixed montane forests on limestone boulders and north-exposed rock outcrops as well as in torrential floodplains, where they even reach a secondary optimum at elevations below 700 m. These statistical relationships indicate that it is possible to develop area-wide models of the potential distribution of lithic histosols based on existing geodata.
Ellenberg nutrient values of vascular plants growing on lithic histosols indicate oligotrophic (53%) to very oligotrophic conditions (27%) with wide C/N- and C/P-ratios as well as low K supply, which severely limits height growth of trees and associated ecosystem functions despite considerable storage of water, C and nutrients. Global change is likely to favour losses of thick forest floors through warming-induced mineralization (with concurrent CO2-emissions) and increased whole-tree harvesting, which may ultimately threaten the ability of certain sites to support forest at all.

ecosystem services, forest floor, mountain forest

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-448 **Forest floor in Southwest Germany - properties and changes within the last decades**

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Abstract: Forest floor properties vary strongly in space and time. Results from the repeated National Forest Soil Inventories (NFSI) in Baden-Württemberg in Southwest Germany show a sensitive soil compartment, which has undergone a significant reduction in total mass and a change in several chemical and physical properties. Basic properties like humus form, total mass and chemical composition are directly connected to natural circumstances like parent material of the mineral soil, stand type and climatic conditions. Latter change within time and thus do the forest floor properties. On the one hand global change with rising temperatures and changes of the precipitation regimes should have a distinct influence. On the other hand anthropogenic influences like deposition of heavy metals and acids have been reduced distinctly (with exception of nitrogen) while silvicultural measures like the conversion of forests and forest liming are historical and recent factors, which all directly and indirectly influence forest floor horizons.
Due to the complex nature of the described circumstances, a simple explanation for the changes of the forest floor properties in the last decades cannot be expected. The complexity has to be approached by multivariate statistics, which help to understand some processes. Nevertheless the majority remains unexplained and further monitoring is crucially needed.

forest floor, soil inventory, nutrients

Theme 5: Forests, Soil and Water Interactions

18 - Forest floor matters - The pivotal role of a forest compartment in danger of extinction

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-4132 **Has long-term elevated N-deposition changed organic layer accumulation, microbial community, reactivity and temperature sensitivity?**

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Abstract: There is evidence that nitrogen (N) fertilization increase organic matter accumulation in forest floors but the effects of elevated N deposition on soil organic matter (SOM) is still uncertain. We used a short (100 m) 'natural' N deposition gradient (18-30 kgN/ha/yr) inside a forest edge downwind from intensive agriculture to study the effects of several decades of elevated N deposition on organic layer amount, reactivity, temperature sensitivity and microbial community composition. The N enrichment had decreased the organic layer C/N from 30 to 23 along the gradient and caused a minor increase in the amount of SOM. Decomposition rate as well as its temperature sensitivity (Q10) decreased with decreasing C/N ratio (N enrichment). Bacterial indicators increased with N enrichments. Results from four other less intensively studied forest edges will be included in the presentation. We conclude that N deposition reduce decomposition rate and change the microbial community. However we only found higher accumulation of SOM at the lowest deposition levels investigated. We hypothesize that reduced below ground litter input outweigh any effects of reduced decomposition on SOM amount at high N-deposition.

Organic layer, C/N, decomposition, N-deposition

Room "Basel + Mühlhausen" (Novotel Freiburg)

IUFRO17-740 **Forest management can counteract recent forest floor degradation induced by climate warming in mountain forests of the German Alps**

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Abstract: Recent climate warming has induced marked decreases of forest floor thickness and organic matter stocks in forest soils of the German Alps. This is particularly the case for sites with calcareous parent material, which most often are characterized by shallow, stony soils with small contents of water- and/or nutrient-retaining soil minerals and an insufficient supply of important nutrients (N, P, K, Mn, Fe) to forest trees. At such sites, the forest floor is particularly important as rooting space and for water and nutrient storage, thus being a crucial factor for tree and stand vitality, regeneration success, and ultimately sustained provision of important protection functions (e.g. against avalanches, surface runoff, erosion) of mountain forests in the Alps.
Fortunately, the general trend of recent forest floor thickness and soil organic matter stock decrease can be reversed by appropriate forest management. This is shown for two mixed mountain forest sites in the German Limestone Alps (Langenau, Mangfallgebirge; Seinsbach, Karwendel). At each site, adjacent stands with similar initial stand and soil properties, but different forest management regimes during the recent 50 years (Langenau) and 65 years (Seinsbach) are compared with respect to stand density, important soil properties including forest floor thickness and chemistry, as well as stand nutrition. At both sites, similar changes of either forest floor degradation or recovery, depending on forest management - with regulation of ungulate density being the most important factor - could be observed. Forest floor changes were associated with changes of stand density, composition, and structure, soil fertility, and stand nutrition.

mountainforest, climatechange, management, O layer

Theme 5: Forests, Soil and Water Interactions

48 - Ecohydrology-based forest management for water provision, carbon sequestration and enhanced

KG I - Aula (Uni Freiburg)

IUFRO17-2572 **Forestry and water budget in Germany - conseqences for choice of tree species and for forest management**

Müller, J.* (1)

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Abstract: In region with low precipitation forest, hydrology research looks into the influence of differently structured forest on the landscape hydrology and on the components of the hydrologic equation. The aim is to provide scientific guidance in the development of productive forests that enhance the quantity and quality of seepage water under the condition of climate change.
The main topics of the hydro-ecological investigations are:
###Role of the forests in the landscape water balance?
###Water consumption and tree growth at decreasing water resources?
Methods
Large-scale lysimeters with a depth of 5 m and a surface area of 100 m2 (10x10 m) were planted with the tree species Scots pine, European beech, European larch and Douglas fir. To investigate the impact of intensified drought on forest regeneration and tree growth special weighable small-scale lysimeters were constructed and used.
Results
The tree species and the age, the vertical structure and mixture of the trees as well as her management influence substantially the amount of the groundwater recharge. Evaporation and groundwater production are functions of the tree structure parameter and the tree growth. In the long run, the pine-beeches-mixed stands also makes a positive contribution to the landscape water balance.

lysimeter, water budget, tree species, drought

KG I - Aula (Uni Freiburg)

IUFRO17-2630 **Impacts of Wildland Fires on Streamflow in the United States: Empirical Evidence and Modeling Results**

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Abstract: Forest fires are perceived to have great impacts on watershed hydrology and ecosystem services such as water supply and carbon sequestration by altering ecosystem structure, soil properties, flow pathways, and evapotranspiration rates. However, rigorous and systematic studies on the hydrological effects of wildland fires at the watershed to basin scales are uncommon, and our knowledge about the relationships between wildland fires and water resources is lacking. Land managers ask important questions about the consequences of fire management options such as frequent prescribed burning on water yield. Our study examined the different hydrological responses to large wildfires or forest treatments across several physiographic regions in the continuous United States (CONUS). These watersheds were selected based on burned area and burn severity records, and streamflow and climate data availability. We have developed a general framework for assessing hydrological impacts of wildland fires that captures a wide range of fire types, watershed characteristics, climate conditions and streamflow regimes. Applications of the framework to over a 100 watersheds across the U.S. suggest that the hydrological effects are site specific and extremely variable. The key influential factors include post-fire climatic conditions (rainfall amount and variability, snowfall), burned area, watershed characteristics (slope and vegetation types). We conclude that detecting the true hydrologic impacts of wildfires require a process-based modeling approach that captures the large spatial and temporal variability in watershed hydrology and complex interactions between wildland fires, soils, climate, and vegetation recovery.

Wildland Fires, Hydrology, Watershed Management

KG I - Aula (Uni Freiburg)

IUFRO17-3372 **Potential biomass-water synergies in dryland farming systems**

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Abstract: Addressing climate change with mitigation strategies via bioenergy systems integrated with the land sector can result in competition for land and water. For example, biofuel from 1st generation pathways is nutrient and water intensive, in contrast, lignocellulosic or 2nd generation biofuels can be more efficient in nutrient and water demands and can be produced on marginal land.
In Australia the deforestation of 100 Mha of natural forests in low rainfall regions for the establishment of agriculture has resulted in extensive landscape hydrological imbalance and is characterized by an accumulation of soil water and resultant dryland and water resource salinity. Reforestation for salinity control can potentially take advantage of excess soil water in an otherwise low rainfall environment, thus giving rise to water-biomass synergies.
The development of new ways of integrating forestry into farming systems via species selection and silvicultural regimes has enabled the manipulation of soil water for landscape hydrological restoration. New carbon inventory systems have been developed including measurement of root systems and above ground biomass. These developments are globally applicable to forest carbon mitigation projects in other dryland areas.

Theme 5: Forests, Soil and Water Interactions

48 - Ecohydrology-based forest management for water provision, carbon sequestration and enhanced

KG I - Aula (Uni Freiburg)

IUFRO17-1304 **Eco-hydrological effects of forest management of Aleppo pine post-fire regeneration forest at catchment scale**

González-Sanchis, M.* (1); Ruiz-Pérez, G. (2); del Campo, A. (1); Francés, F. (1); Lidón, A. (1); Martínez, F. (1); Bautista, I. (1); García-Prats, A. (1); Lull, C. (1)

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Abstract: Wildfires are very common in the Mediterranean basin, and the natural post-fire regeneration usually leads to extremely high density stands of Aleppo pine (>30.000 tree/ha). While this situation can initially play a role against soil erosion, its extension through time can compromise the ecosystem services by decreasing tree vigour, landscape and recreational value, water yield and increasing the wildfire risk. However, despite this loss of ecosystem values, these regeneration stands are usually abandoned as nowadays its management does not result cost-effective. Forest management is usually only focused on productive functions (timber, pulp, cork...), and this kind of regeneration stands show low productive value. Nevertheless, when other functions as valuable as the water yield are included into the management scheme, the cost-effectiveness should be reformulated. Water availability in the Mediterranean basin is scarce and is mainly dependent on runoff from mountain areas, which can contribute to 50-90% of the total supply. Including this water yield into the forest management scheme might increase the cost-effectiveness as well the interest in performing it. Thus, analysing and quantifying the eco-hydrological effects of the forest management under a very common situation in the Mediterranean basin as it is the post-fire Aleppo pine regeneration, becomes unavoidable in order to face the present and future water scarcity problems. The present study analyses and quantifies the eco-hydrological effects of forest management of Aleppo pine post-fire regeneration on the catchment water yield. To that end, a semiarid Mediterranean catchment is selected (Carraixet, E Spain), whose upper part is mainly occupied by post-fire Aleppo pine regeneration forest. Hydrological modeling (TETIS-VEG model) combined with field data and satellite imagery are used in order to analyse and quantify the total water yield contribution of this forest under managed and unmanaged scenarios.

ecohydrology,forest good & services,water scarcity

KG I - Aula (Uni Freiburg)

IUFRO17-2116 **Assessment of the water retention potential of forest soil for clean water supply**

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Abstract: Forests play a critical role as clean water retention sources, covering 64% of the total area of South Korea. The importance of forest's role is bigger and bigger in the era of climate change. This study provides for the first time to assess the role of forests in water retention, based on the spatial distribution of forest soil water retention capacity in South Korea. Pilot study was carried out in three counties, located in the major clean water supply source area of South Korea. Soil water retention curves (SWRC) of forest soils were made and used to assess water retention potentials of forests. Also, van Genuchten model was used to describe soil water retention. Undisturbed forest soil samples were collected from 300 points in 2016, and soil water content relationships for each soil sample were established using the pressure plate apparatus. We also investigated soil characteristics (i.e., bulk density, soil texture classes, parent rock, organic matter content and so on), geomorphological parameters (i.e., slope, altitude, aspect, curvature and topographic wetness index), and forest conditions (e.g., forest type, dominant tree height, average DBH, density, age class and management) to develop pedotransfer functions (PTFs) to estimate four key model parameters of van Genuchten models. The results showed water retention potentials of forest soil has strong relations with forest conditions such as forest type, dominant tree height, average DBH and age class as well as soil characteristics such as soil bulk density, soil particle distribution and organic matter content.

Water resources conservation, PTFs, van Genuchten

KG I - Aula (Uni Freiburg)

IUFRO17-3122 **Forest soil water budgets under a changing climate - modelling framework and example application to the forests of Baden-Württemberg, Germany**

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Abstract: The manifold attempts to understand the effects of climate change on the vitality and productivity of forests in recent years have increased demands on the estimation and forecasting of forest soil water balances. We developed a high-performance modelling framework with the aim to model daily soil water balances with a spatial resolution of 250x250m. Core of the modelling framework is the soil water balance model LWF-Brook90. As meteorological drivers, present climate data as well as three future climate projections (RCP2.6, 4.5, 8.5) were used. Comprehensive soil information for the forest stands were derived from the German Forest Soil Inventory. Two stand types (beech, spruce) were simulated, which differed mainly in their phenological parameters. The modelling resulted in daily values of the site water balance (e.g. canopy interception, soil evaporation, transpiration, deep drainage) as well as the daily soil-internal water status (soil matric potential, content and fluxes in up to 30 simulation depths). From the model outcome, various drought indicators (e.g. transpiration deficit, relative available water capacity, exceedance of critical levels of soil water content and soil matric potential) were derived. The comparison of the two climate projections with the present climate shows how the increased temperature and the changed precipitation regime increase the drought risk of forest stands. Also, the considered tree species had a large impact on the modelled drought risk, since beech was connected with lower canopy interception, higher rainfall infiltration and hence, lower drought risk. Our model application demonstrates how the developed modelling framework can be used to assess and compare different mitigation strategies to counteract the effect of global warming. Next, the model results will serve as a database to better predict the risk of spruce bark beetle infections and changes in beech fructification, due to an increasing drought probability.

soil water model, LWF-Brook90, drought

Theme 5: Forests, Soil and Water Interactions

48 - Ecohydrology-based forest management for water provision, carbon sequestration and enhanced

KG I - Aula (Uni Freiburg)

IUFRO17-706 **Thinning management increases tree growth by delaying the drought onset in a Mediterranean evergreen oak coppice**

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Abstract: Forest management by thinning is known to improve tree growth and resistance to stress due to a reduced competition for resources. In strongly water limited ecosystems such as Mediterranean woodlands, thinning effect occurs mainly through an improvement of the water balance. Building on the recent advances regarding the 'sink limitation' paradigm that demonstrated a direct control of tree growth by phenology and climatic constraints decoupled from the carbon assimilation, we investigated if the thinning effect on tree growth could be predicted by a water balance model in a Mediterranean coppice. We used results from a long-term thinning experiment (30 years) conducted in a Quercus ilex forest in southern France and from a 12 years rainfall reduction experiment in plots with different tree densities to test our hypothesis. Thinning resulted in significantly increased stem growth and reduced mortality of the remaining stems. Integrating the change in leaf area due to thinning in a water balance model, together with knowledge on tree growth phenology, allowed to predict the thinning effect on growth with a good accuracy for moderate thinning intensity treatments. Experimental and simulation results both indicate that drought onset is delayed by thinning, which explains most of the growth increase. Our simple predictive model based on the simulation of the water balance as a function of tree density and leaf area opens the way to simulating Quercus ilex growth at a broader scale and under different climate change scenarios, and could be used as a management tool to optimize the tree density as a function of current or future water limitation in Mediterranean evergreen woodlands.

Thinning, water stress

KG I - Aula (Uni Freiburg)

IUFRO17-2767 **Water status and water use of temperate European forest tree species during naturally occurring drought**

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Abstract: A lot of research in the recent past has focused on tree water relations during drought. Yet, most of these studies only focused on selected physiological and morphological traits such as sap flux, stomatal conductance or wood anatomy. For a deep and sustained knowledge about whole-tree responses to drought it is, however, very important to integrate a variety of traits into the study design.
We investigated the water use and water status of mature individuals of six different European forest tree species during three growing seasons from 2014 to 2016 in a near-natural 130-year-old forest near Basel, Switzerland, and applied a variety of tools to investigate the species' response to short-term limitations in water supply. We combined sap flux readings, high resolution radius measurements and in-crown stomatal conductance and water potential measurements and identified the species' soil water sources by the application of deuterium-labeled water.
First results of our study show that there is evidence for different species-specific strategies for water acquirement and use during both wet and dry periods. Especially during drought, the ring-porous species Q. petraea seems to exhibit the greatest resilience in terms of water availability and use probably due to the tapping of deeper water sources. Further findings are in process.

rooting depth, adult trees, sapflow, TWD, isotopes

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IUFRO17-4088 **Defining the Concept of Hydrologic Space**

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Abstract: Deforestation leads to more local runoff and reduced precipitation. However, the importance of afforestation in contributing to the flow of atmospheric moisture and promoting precipitation recycling is underappreciated. Since much of the evapotranspiration from forests falls again as precipitation, the terrestrial, forest-based production of atmospheric moisture has important consequences, both for local and downwind precipitation and water availability. We emphasize the importance of inter-basin connectivity. Spatial interconnectedness is poorly reflected in the study of land-atmosphere interactions and the contribution of forests to the hydrologic regime. Focusing on the supply-side characteristics determining rainfall, we define and develop the concept of hydrologic space and apply the concept to the derivation of the catchment basin water balance. Conventional approaches to c-basin water balance typically fail to consider the import and export of atmospheric moisture as a principal determinant of locally and regionally available water supply. We develop an explicit model for predicting the potential impact of land use change on precipitation recycling for local and continental precipitation and illustrate the hypothetical consequences of change in forest and vegetation cover on local and regional scales using data from a series of Swedish catchment(s). Land use modification has important implications for the availability of atmospheric moisture, the production of precipitation, the re-export of available moisture and the availability of runoff: the total amount of water available for productive and consumptive purposes. These consequences are not adequately recognized in most policy efforts at multiple scales and levels of governance.

Forests, Water, Hydrologic Cycle, Adaptation

Theme 5: Forests, Soil and Water Interactions

88 - Natural hazards and disturbance interactions in mountain forests

KG I - Aula (Uni Freiburg)

IUFRO17-2178 **Post-fire regeneration monitoring: integrating field-based and remote sensing at different spatial scales**

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Abstract: Improved monitoring and management of post-fire forest regeneration is required worldwide to face alterations in fire regimes, associated with increasing size, frequency and severity of events, due to global change. This is particularly critical within ecosystems whose main species do not present specific fire adaptations. Understanding how to increase the resilience of these ecosystems and promote post-fire regeneration processes thus becomes a major goal.
Regeneration strategies were compared in terms of timing and efficiency of the restoration process. This general goal was achieved on recent (last 15 years) stand-replacing fires of the Alps and the Apennines. We used different remote sensing (LANDSAT, LiDAR and UAV) and field-based data to monitor the post-fire regeneration patterns. Salvage logging and active management were carried out in some of the Alpine areas. We contrasted recruitment patterns for each management option, analyzing the influence of biotic and abiotic factors.
The performed analyses allowed assessing regeneration dynamics ranging from microsite to the whole landscape. At fine-scale facilitation provided by both standing and downed deadwood creating safe sites for germination proved to be crucial for successful regeneration of seeder species. At landscape-scale the forest regeneration index (FRI) proved to be a better regeneration indicator of post-fire forest recovery than other well-known vegetation indices (e.g. NDVI, NBR).
Post-fire management greatly affected the capacity of the ecosystem to restore, acting on biological legacies and altering the variety and abundance of microsites.
New technologies providing high resolution information and able to acquire geographic data "on demand" demonstrated great potential for monitoring post-disturbance recovery dynamics of vegetation.

Post-fire, LiDAR, restoration, Alps, Apennines

KG I - Aula (Uni Freiburg)

IUFRO17-3673 **30 years of research and transfer on protection forest against rockfall risks in France and Europe**

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Abstract: Mountain forests are multifunctional ecosystems but an efficient and sustainable forest management and land use strategy have to be based on the definition of priority functions. This could only be done if efficient knowledge and decision support systems are developed in order to identify, qualify, quantify and prioritize the different forest ecosystems services. Since 30 years now, the team Protection-Ecological Engineering -Restoration (PEER) of the Irstea regional research center of Grenoble is working on these actions for valorizing the forest rockfall protection ecosystem service in French and European rockfall mitigation and protection policies. The data and knowledge acquired through the development of innovative experimental protocols (real size experiments) has allowed the development of effective models (1, 2 and 3D rockfall trajectories models integrating the effect of forest stands, tree biomechanical behavior model based on the discrete element method, forest resources and dendrometrical parameters mapping with LiDAR data, dendrogeomorphological analysis), silviculture guidelines and forest policies. This presentation will summarize the main milestone and results of these 30 years of research but also the scientific and applied perspectives for the future.

Protection forest,rockfall,modelling,guidelines

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IUFRO17-501 **Post-fire trends in the protective capacity against rockfall of European beech forests (Fagus sylvatica L.) in the southwestern Alps**

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Abstract: Since global warming may increase fire disturbance in historically non fire-prone regions, questions arise on the effect of fire in the protective capacity against rockfall of mountain beech forests.
We studied temporal trends in the protective capacity of 34 beech stands that burnt once between 1970 and 2012 in the southwestern European Alps. We evaluated forest structural characteristics resulting from mixed-severity fires and subsequently applied the Rockfor.net model to asses the protective capacity against falling rocks comparing different scenarios combining rock volumes, lengths and gradients of the forested slopes.
Burnt beech forests hit by low-severity fires maintain a protective capacity similar to the unburnt forests, because only thin fire-injured trees die while intermediate-sized and large-diameter trees mostly survive. Contrastingly, the protective capacity after moderate- and high-severity fires is significantly reduced; especially between 10 and 30 years post-fire when the progressive tree mortality minimizes the stand density. In those cases, post-fire restoration measures should be timely planned within the first five years. Beside the installation of rockfall nets or dams, small-scale directional felling of dying trees oblique to the slope synchronized with beech masting should be applied to mitigate the temporary reduction in the protection capacity and enhance beech regeneration.

forest fires, burn severity, Rockfor.net

Theme 5: Forests, Soil and Water Interactions

88 - Natural hazards and disturbance interactions in mountain forests

KG I - Aula (Uni Freiburg)

IUFRO17-1108 **Tradeoffs between efficiency of the protection against rockfalls and vulnerability to fires in the French Alpine forests**

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Abstract: A significant part of Alpine forests are located between starting areas of rocks and areas of human activities. These forests are natural barriers against rockfalls and contribute in reducing the risk of human casualties and damages to infrastructures. This particular ecosystem service can unfortunately be disrupted by events such as fires, likely to be more frequent in future years due to climate changes and socio-economic trends.
The aims of this study are 1) to evaluate which protection forests against rockfall are subjected to fires, 2) to analyze the consequences of different fire scenarios on their capacity to reduce natural hazards and 3) to identify forest management practices that could optimize the tradeoffs between rockfall protection and fire vulnerability.

First, a functional analysis for each natural hazard was carried out on 4427 different stands located in all the French Alps. Quantitative indicators were defined to evaluate the protective effect of a forest against rockfall and the tree mortality after different fire scenarios. Second, a multi-risk analysis was performed in order to compare the indicator of rockfall protection before and after a fire event. Finally, the influence of forest structure and composition on the optimal trade-off was investigated.

Alpine Forest;Rockfall;Forest Fire;Climate Changes

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IUFRO17-2301 **How far can one throw a rock through a forest until it hits a tree? - A Boolean model approach**

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Abstract: Rocks traversing forested hill slopes can have a high chance of being stopped within the forest as a consequence of energy losses induced by tree hits. The forest-rock interaction can be characterized as a combination of hit-frequency and dissipated energy per hit. The mean tree-free distance (MTFD) is a common proxy for hit-frequency. It estimates the distance between two tree hits in a forest based on the assumption that trees are arranged in a rectangular grid. Furthermore, the resulting distance value is assumed to be the mean distance. We present a Boolean model which enables the assignment of exceedance probabilities to arbitrary tree-free distances. The model assumes that (1) trees are randomly distributed according to a Poisson point process and (2) discs placed at tree locations represent contact areas within which rocks hit trees. Assuming that a rock follows a linear trajectory between two hits, the exceedance probability can then be calculated as a negative exponential function of tree-free distance. Interestingly, the expected value of tree-free distance based on that function equals the MTFD because the corresponding formula is convertible into the MTFD-formula. This novel approach facilitates the probabilistic modeling of hit-frequency and provides a theoretical base for the interpretation of the MTFD.

rockfall, protection forest, Boolean model

KG I - Aula (Uni Freiburg)

IUFRO17-2383 **Bark beetle disturbance alter forests' protective effects against snow avalanches**

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(1) Utah State University, Department of Wildland Resources, Logan, UT, United States; (2) WSL Institute for Snow and Avalanche Research SLF, Davos Dorf, Switzerland; (3) US Forest Service, Interior West Forest Inventory and Analysis, Bozeman, MT, United States

Abstract: Bark beetle-induced tree mortality changes forest cover, which may alter the effects of mountain forests in protecting people, settlements and infrastructure against snow avalanches. Forests growing in avalanche terrain reduce the likelihood of avalanche release by inhibiting the formation of spatially continuous weak layers within the snowpack.

We examined snowpack in an Engelmann spruce forest in the central Rocky Mountains, Utah, USA, using a high-resolution penetrometer (SnowMicroPen). Data were collected in plots beneath canopies of undisturbed (green), bark beetle-disturbed (gray) and salvage logged forest stands. Repeated measurements were collected in 2015 (2016) along 10 (20) m transects at 0.3 (0.5) m intervals. Using a statistical model, we derived 2-D snow density profiles as a measure of snow stratigraphy. Small-scale snowpack heterogeneity was higher beneath green and gray trees; however, more homogeneous layering developed during periods of less snowfall where unloading or melting of intercepted snow is reduced and snow metamorphism is the dominant process influencing snow stratigraphy. Snow stratigraphy was consistently more homogeneous in the harvested stand despite small-diameter trees and woody debris being present.

As mountain forests become more prone to mass attacks associated with climate change, our results suggest to review forest management practices following bark beetle disturbance.

snow avalanches, protection forest, disturbance

Theme 5: Forests, Soil and Water Interactions

88 - Natural hazards and disturbance interactions in mountain forests

KG I - Aula (Uni Freiburg)

IUFRO17-3080 **Estimation of Debris Flow Impact force from the flume experiments**

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Abstract: Debris flow is a fast movement of soil-water mixture flowing a confined channel of mountain terrain. It is a type of mass movement that involves water-charged, predominantly coarse materials flowing rapidly down along a steep confined, pre-existed channel. To control debris flow hazard, mitigation measures such as debris barrier are implemented in mountain areas. When debris flow control structures are designed, accurate understanding on flow behavior and corresponding impact force is required. In this study, flume experiments were conducted to estimate the impact force of debris flow with different soil mixture composition and flume slope conditions. Using 200 mm (W) x 300 mm (H) x 2,000 mm (L) flume apparatus, debris flow characteristics, such as front mean velocity and maximum depth, and corresponding impact force were measured in the experiments with four different mixing ratio and slope of 25 °, 30°, 35°, and 40°. Flow velocity and impact force was correlated with mixture composition, especially clay contents, and slope conditions. Flow depth did not show significant difference along mixture composition and slope conditions. Flow velocity and corresponding impact force were significantly correlated with each other.

Debris flow, Flume, flow behavior, Impact force.

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IUFRO17-233 **Plant-Best: a novel plant selection tool for slope protection**

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(1) School of Engineering and Built Environment, Glasgow Caledonian University, Glasgow, United Kingdom

Abstract: The aim of this talk is to introduce Plant-Best, a novel tool
for plant selection and the identification of the most suitable plant cover against rainfall-induced shallow landslides. Plant-Best explores the plant-derived likelihood reduction of slope failure under wetting and drying events, respectively. It comprises five comprehensive open-source modules built in the freeware R. The modules' objectives range from the spatial detection of shallow-landslide-prone zones to the integrated
evaluation of plant-derived hydro-mechanical effects on sloped terrain; from the selection of the best performing plant species to the identification of sensitive plant traits. In this talk we provide a detailed description of the Plant-Best modules and we show how this holistic tool can be effectively employed for plant cover selection in a landslides context.
We also demonstrate the application of Plant-Best on a site with a history of slope failures in Northeast Scotland and its implementation using seven representative plant species including both woody and herbaceous plants. Our results reveal that different plant species were suitable for protection depending on the hydrological conditions -i.e. wetting or drying. Plant effects were limited to the topmost soil and, in
general, underweight plants with dense root systems and broad thick canopies had the best resistance to failure. These suggested that diverse slopes with different plant functional groups are desirable for a more effective soil protection.
Plant-Best proved to be a simple and robust tool for the detection of landslide-prone zones, the selection and evaluation of plant covers and the identification of relevant plant traits related to shallow landslides mitigation. The open-source nature of the tool confers a great versatility and applicability to the tool which can be deployed as a multi-disciplinary aid to the decision making process.

Plant selection Landslide Model Slope protection

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IUFRO17-2385 **Managing Forest Disturbance in a Changing Global Ecosphere: metaphysical, socio-political and ecological opportunities and constraints**

Jenkins, M.* (1)

(1) Dept. Wildland Resources, Utah State University, Logan, United States

Abstract: In this presentation Dr. Jenkins explores natural disturbance regimes in western North American forests as complex webs of interacting and interrelated social, political, biological and ecological elements.
A forest disturbance is a discrete event that alters the successional trajectory by creating openings that provide opportunities for other plant species to establish. Agents of disturbance may be biotic as, for example bark beetles, or abiotic such as fires or snow avalanches. The specific agent may affect a single tree creating a small gap in the forest canopy or may operate at the landscape scale over tens of thousands of hectares. It is the effect of agents of disturbance over large spatial and long temporal scales that determine landscape level forest vegetative composition and structure. Discussions of forest disturbance often center on natural agents and impacts that have been part of normal forest cycles over millennia. The reality of climate change, invasive species, carbon supply and increased human demands on resources alter natural disturbance regimes threatening ecosystem integrity. When disturbance events intersect human values management action may be desirable, but is often at odds with public opinion and frames the debate between developers and conservationists.

Theme 5: Forests, Soil and Water Interactions

50 - Soil Processes and Sustainable Forest Management (IUSS)

KG I - 1199 (Uni Freiburg)

IUFRO17-2956 **Consequences of mineral fertilization and biosolid application on nutrient leaching over an entire rotation in Brazilian eucalypt plantations**

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Abstract: Large amounts of fertilizers are applied in tropical planted forests managed in short rotations to sustain high biomass productions in highly weathered soils. Our study aimed to assess the consequences of fertilizer and biosolid additions on groundwater quality and nutrient leaching in Eucalyptus grandis plantations. Soil solutions were continuously sampled in 9 plots using plate lysimeters and ceramic cups at depths of 15, 50, 100 and 300 cm. The solutions were collected every week over 6 years to determine the concentrations of the main anions and cations. Three treatments were studied in 3 blocks: no nitrogen addition (control), 120 kg N ha-1 applied as ammonium sulphate, and 30 t ha-1 of biosolid added containing 1260 kg N ha-1. The main biogeochemical processes controlling the chemistry of gravitational solutions throughout their transfer were identified. The chemical composition of soil solutions in the topsoil was driven by the mineralization of soil organic matter and harvest residues as well as the dissolution of the fertilizers. The peaks of nutrient concentrations reached a depth of 1 m about 9 months after planting but high concentrations never reached a depth of 3 m, except after the last biosolid application. E. grandis trees exhibited a remarkable filter capacity against nutrient leaching as a result of i) a relatively slow transfer of mobile ions in deep soil layers, ii) a very fast root growth (down to > 6 m at 1 year after planting) and iii) a high demand of trees in water and nutrients from 6 months after planting onward. Our results suggest that the number of fertilizations could be reduced in commercial eucalypt plantations growing in deep Ferralsols and that biosolid applications could be adjusted to reach high growth rates without polluting deep water tables.

soil solution, biogeochemistry, management, Brazil

KG I - 1199 (Uni Freiburg)

IUFRO17-2075 **Long-term fate of applied nitrogen in managed pine ecosystems of the southeastern United States using 15N**

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Abstract: A long-term study was initiated in 2011 to refine mechanistic understanding of ecosystem partitioning and retention of applied fertilizer nitrogen (N) in managed pine ecosystems of the southeastern United States using 15N. In addition, the efficacy of enhanced efficiency N fertilizers (EEFs) was compared to urea for different application seasons (winter, spring, summer) to increase fertilizer N use efficiency (FNUE) and sustainability of fertilization in these ecosystems. Fertilizer N loss from the system was determined using microcosm experiments, while ecosystem partitioning-retention was calculated with mass balance equations after sampling ecosystem components. Fertilizer N losses were significantly less for EEFs (4-26%) compared to urea (26-49%) for spring and summer, and NBPT was less than urea in winter. Lower fertilizer N losses for EEFs directly translated to increased fertilizer N ecosystem retention (77-84%) compared to urea (52-56%) for spring and summer, and for NBPT compared to urea in winter. Six years after fertilization, more fertilizer N remained in the soil for EEFs (10-25%) than urea (5-15%). This finding may translate to an increase in FNUE for current and subsequent stand rotations if the residual fertilizer N in the soil becomes bioavailable to desired tree species. This research highlights how EEF technology can increase FNUE and sustainability of N fertilization in managed forest systems.

15N, enhanced efficiency fertilizers

KG I - 1199 (Uni Freiburg)

IUFRO17-1720 **The impact of secondary forests conversion into larch plantations on C, N, P, K, Ca and Mg concentrations and stocks in forest floor and soils**

Yang, K.* (1); Zhu, J. (1); Xu, S. (1); Xiao, J. (1); Yu, L. (1)

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Abstract: Larch plantation is widespread in northeastern China, however, knowledge of how and to what extent change macronutrient (C, N, P, K, Ca, Mg) concentrations and stocks in forest floor and soils after conversion of natural secondary forests to larch plantations is scarce. This study aimed to assess C, N, P, K, Ca and Mg in forest floor and soils under larch stands against the secondary forest stands. Four pairs of larch plantations and secondary forests were randomly selected from a mountainous area.

The conversion of natural secondary forests to larch plantations effects on macronutrient concentrations and stocks were mainly found in the forest floor and in the 0-10 cm soil depth. The forest floor litter stock significantly increased while the concentrations of K and Ca significantly decreased in the larch plantation. In the soil, the concentrations of C and N concentrations were significantly lower, and the concentrations of K and Mg were significantly higher in the larch plantation stands than in the natural secondary forest stands; whilst the concentrations of P and Ca were comparable between the two forest types in the 0-10 cm depth. The difference of tree species between secondary forest and larch plantation stands might influence litter nutrient concentrations, litter decomposition rates and plant uptake of macronutrients among the species and thus modify soil macronutrient concentrations.

The C, N and P stock in forest floor significantly increased in larch plantation stands than those in secondary forest stands. In the soil, the C stock decreased whereas K and Mg stocks increased in the 0-10 cm soil depth. There was not significant N, P and Ca stocks between two forest soils. Overall, conversion of secondary forests to larch plantations in the region is more likely to cause above- and belowground macronutrient reallocation than to result in reduction in overall macronutrient stock.

Larch plantation; Secondary forest; Macronutrient

Theme 5: Forests, Soil and Water Interactions

50 - Soil Processes and Sustainable Forest Management (IUSS)

KG I - 1199 (Uni Freiburg)

IUFRO17-3115 **N2O and NO fluxes from different land uses in the Mau Forest Complex, Kenya: An incubation experiment with intact soil cores.**

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Abstract: Land use change (LUC) from tropical forest into intensively managed systems is driven by the increasing demand for food and fibre by a growing population. However, how such changes affect the soil-atmosphere exchange of greenhouse gases is still not well explored, especially in Africa. Such LUC effects were examined in the Mau Forest Complex region- the prime tea producing area for Kenya. For this, intact soil cores were taken from the dominating land uses, i.e. natural forest, commercial and smallholder tea plantations, eucalyptus plantation and grazing land. Soil cores were incubated under controlled soil moisture conditions and fluxes of soil N2O and NO were quantified. Annual fluxes were calculated using in-situ monitored soil moisture changes and results of our parameterization experiments. For forest and eucalyptus sites our approach yielded annual flux estimations of 0.3-1.3 kg N2O-N ha-1 year-1 and 2.1-5.2 kg NO-N ha-1 year-1. Highly fertilized soils of commercial tea plantations showed significantly higher emissions (0.9 kg N2O-N ha-1 year-1 and 4.3 kg NO-N ha-1 year-1) as compared to smallholder tea (0.1 kg N2O-N ha-1 year-1 and 2.1 kg NO-N ha-1 year-1) and grazing land (0.1 kg N2O-N ha-1 year-1 and 1.1 kg NO-N ha-1 year-1). High NO emissions were due to long-term nitrogen fertilization and subsequent soil acidification promoting chemodenitrification. Our laboratory study shows an approach which can be used to obtain better knowledge on the effects of LUC on soil-atmosphere trace gas exchange for understudied regions. Results can also be used to validate mechanistic biogeochemical models.

Nitrous oxide ;nitric oxide;tropical forests; LUC

KG I - 1199 (Uni Freiburg)

IUFRO17-3185 **Soil nutrients and fractions. Forest management : climate change 1 - 0**

Lanfranchi, M.* (1); Vanguelova, E. (2); Weatherall, A. (1)

(1) University of Cumbria, National School of Forestry, Ambleside, United Kingdom; (2) Forest Research, Forestry Commission, Farnham, United Kingdom

Abstract: Harvest intensification, such as brash harvesting (BH), can increase the supply of biomass for bioenergy. However, the effects on soil carbon (C) and nutrients are not well understood. For BH to help combat climate change, the soil C and nutrient stocks and fluxes must not be adversely affected.

The aim of this study is to determine the effects of BH on soil C in three forest sites in the UK covering a range of soil nutrient regime from 'medium' to 'very poor' as defined in the British Ecological Site Classification. In each forest, three treatments were implemented during the nineties: clearfell (CH, brash retained), CH + fertilization, BH.

Eight hundred observations were taken in November 2016. These will be analysed to quantify P, K, Mg, Ca (using an unbuffered BaCl2 solution and determined by inductively coupled plasma optical emission spectrometry) within the mineral and organic horizons; the latter will also be assessed on the total and available N by KCl extraction.

Benefiting from COST Action FP1305, a novel soil fractionation technique will quantify the soil C pools in the organic layers. For lignin analysis, ground litter will be treated with acid detergent solution. Observations will be washed to achieve a neutral pH and rinsed in acetone. Observations will be air-dried, then dried at 105 °C, then cooled and weighed for fibre residue. Observations will be immersed in H2SO4, then washed to reach neutral pH, rinsed in acetone, dried and weighed to determine lignin residue. Observations will be ashed at 525 °C for residual ash mass and lignin concentration.

Results will be presented that show whether CH contributes to higher C and nutrient stocks in the soil. This will determine whether C is more labile in the soil with or without brash.

This study will enable forest managers to decide whether BH is an option that helps forests combat climate change or whether CH maintains soil C and nutrient stocks that also lead to increased tree growth in subsequent rotations.

forest management,soil carbon pools,CO2 mitigation

Theme 5: Forests, Soil and Water Interactions

50 - Soil Processes and Sustainable Forest Management (IUSS)

KG I - 1199 (Uni Freiburg)

IUFRO17-2735 **Effects of forests management on soil functions - results of the national forest soil inventories in Germany**

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(1) Thuenen-Institute for forests ecology, Eberswalde, Germany

Abstract: The condition of the forest soils in Germany has begun to slowly recover since the first national forest soil inventory (NFSI I) in the 1990ies. This is the result of a repetition of the soil inventory in 2006-2008 (NFSI II). The nationwide acidification of the topsoil and depletion of base cations which was observed during the NFSI I can to that extent not be found any longer. The recovery from acidification was more distinct for limed soils than for unlimed soils. In addition, plots with deciduous trees had less acidified topsoils compared to plots with coniferous trees. Carbon storage in the humus layer was higher for coniferous trees than for deciduous trees. Liming resulted in an enhanced C storage in the mineral soil whereas the humus layer lost C. The heavy metal content of soils is determined by the parent material as well as by atmospheric inputs. The latter showed a decline from NFSI I to NFSI II and along with the simultaneous translocation of heavy metals from the humus layer to the topsoil, caused a depletion of heavy metals in the humus layer. This effect is generally enhanced by liming. The reduction of atmospheric deposition particularly of sulfur and lead represents the main reason for the trend towards recovery. In addition, liming of forest soils and forest restructuring from coniferous pure stands to deciduous and mixed stands had an overall positive effect on forest soils even on nitrogen leaching. But, the constant high level of nitrogen (N) deposition is still challenging since N contributes to eutrophication and acidification of forest ecosystems. The evaluations of the NFSI are based on 1,900 plots in Germany and had been published in 2016 (https://www.thuenen.de/de/wo/arbeitsbereiche/waldmonitoring/bodenzustandserhebung/).

carbon nitrogen soil reaction heavy metals liming

KG I - 1199 (Uni Freiburg)

IUFRO17-2578 **Sustainable nutrient supply and maintenance of forest soil through improved liming practices**

Jansone, L.* (1); Hartmann, P. (1)

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Abstract: Since the implementation of forest liming in Germany in 1980s to ameliorate the threat of heavy acid and nitrogen loads on forest soils a number of areas have been limed with varying intensity in Baden-W ürttemberg. Aiming to improve the knowledge base about the effects of liming on soil, soil solution, ground vegetation and nutrient supply of trees and to adapt liming practices to the present-day state and objectives in forest soil protection, the Forest Research Institute of Baden-W ürttemberg (FVA-BW) together with five other federal states is currently participating in a BMEL pilot project for sustainable nutrient supply and maintenance of forests.
12 experimental areas were established in Norway spruce stands and divided in four subareas: limed with dolomite, limed with dolomite-ash mixture, not limed in 2015 (all limed in 1980s and 2003), and a 4th subarea without liming history as control. Samples were collected from humus and mineral soil up to 60 cm depth, soil solution at 60 cm depth and needles from dominant spruce trees. Vegetation was mapped in 10x10 m plots.
While our data analysis is not yet complete, the first results show important differences between limed and not limed plots - above as well as below ground

Liming, Norway spruce, Soil chemistry, Vegetation

KG I - 1199 (Uni Freiburg)

IUFRO17-3819 **Coarse Woody Debris Management for Forest Soil Functioning**

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(1) Albert-Ludwigs-Universität Freiburg, Professur für Bodenökologie, Freiburg, Germany

Abstract: Removal of woody biomass and correspondingly coarse woody debris (CWD) disrupts litter and succession cycles. This disruption affects biodiversity and nutrient stocks, yet its consequences for soil functioning are unclear. Sustainably managing forest soil functioning thus needs answers to interrelated questions of how much CWD affects soil functioning for how long under what conditions. Answering these questions though requires knowledge of the underlying soil processes.

A comparison of Abies alba and Fagus sylvatica CWD in a mixed stand found that species specific decay processes of phenolic matter influenced soil organic matter (SOM) composition, acidity, and nutrient availability next to CWD. From seven additional stands throughout SW Germany, F. sylvatica CWD affected adjacent SOM quality, nutrient content, acidity, and pore structure; though not equally by forest floor type, bedrock, and CWD decomposition. The most noticeable effects were on acidic soils with low biological activity near highly decayed CWD, indicating pedogenic material and biological activity regulate metabolite-driven soil processes. Those differences also imply CWD effects on soil are spatiotemporally limited. Stand level CWD effects will be estimated by up-scaling our results with varying densities. In total, CWD is an essential component of forest soil nutrition especially where soil biological activity is limited.

biodiversity; nutrient cycling; harvest intensity

Theme 5: Forests, Soil and Water Interactions

50 - Soil Processes and Sustainable Forest Management (IUSS)

KG I - 1199 (Uni Freiburg)

IUFRO17-1301 **Spatial patterns of organic matter decomposition in a high mountain forest environment**

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Abstract: Analyses addressing patterns of organic matter decomposition inform about spatial varia ¬tions of soil quality and support decisions for sustainable forest management. In the D.A.CH. project DecAlp soil ecological interactions were investigated in an area in the northern Italian Alps (around Val di Sole, Trentino). The aim of this study was to investigate spatial patterns of decomposition processes by carrying out a field sampling and implementing data-based models from the local to the landscape scale.
Spatial modeling is realized applying a GIS-based approach and using environmental covariates including topography (based on a digital terrain model) and vegetation (based on field estimates of the forest ground cover and a vegetation map). Sample data on humus forms are analyzed using decision tree analysis, random forest and fuzzy logic.
Modeling reveals scale-dependent spatial patterns: There is a high local variability of forest humus forms (closely related to the ground cover and micro-topography), whereas elevation and slope exposure are the main drivers for variations at the slope and landscape scale. The results show that modeling is a useful tool for upscaling of local information on decomposition in a high mountain area with a high potential for monitoring of climate change impacts and for forest management.

Montane forest soil; Humus forms; Spatial modeling

KG I - 1199 (Uni Freiburg)

IUFRO17-3007 **The FACE Wood Decomposition Experiment: Abiotic and biotic controls on the fate of carbon from dead wood**

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Abstract: Dead wood is a significant forest C pool. While major uncertainties about the rate of wood decomposition exist, understanding the interactions between abiotic factors and biological process is fundamental to determining the contributions of C from dead wood on the soil. This information is necessary for assessing the effects of climate change and forest management on ecosystem C sequestration. However, C from wood cannot be differentiated from other sources easily. We address this problem using the depleted wood 13C signature in Pinus taeda, Populus tremuloides, Betula papyrifera grown in two Free-Air Carbon Dioxide Enrichment (FACE) experiments. Logs were placed in 9 Experimental Forests across the U.S. representing a gradient in temperature and moisture regimes in 2011. Logs grown under ambient and elevated CO2 conditions are incubated on the soil surface and suspended without ground contact to emulate the two common positions of dead wood in the forest. Abiotic conditions of the wood are monitored continuously, and samples collected periodically providing the basis for assessing microbial colonization, wood decomposition and movement of C from logs into the soil. After 4 yrs. of decomposition, pine logs on the soil surface had lost 15-55% of the mass, while suspended logs lost 12-30%. To determine the amount of wood C moving into the soil, two end-member mixing models were used. FACE wood C was detectable in the mineral soil at 7 of the 9 sites. The mass of wood C in soil was positively correlated with the rate of mass loss of overlying logs. Less wood C tended to end up as soil C for birch than for aspen or loblolly pine. Climate was a strong driver of decomposition and movement of wood C into mineral soil, with rates being fastest for warm, moist sites. We hypothesize that rot pathway (brown vs white) will become more important as the experiment proceeds, determining the proportion of FACE wood that ultimately resides in stable soil C fractions.

wood decomposition, soil carbon,

KG I - 1199 (Uni Freiburg)

IUFRO17-3031 **Stump harvesting, surface disturbance and time - what happens to C and N pools**

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(1) University of Helsinki Department of Forest Sciences, Helsinki, Finland; (2) SLU, Uppsala, Sweden

Abstract: In this study, the effects of stump harvesting on soil carbon (C) and nitrogen (N) mineralization, and soil surface disturbance were studied in two different clear-felled Norway spruce (Picea abies) sites in Central Finland. The treatments were whole-tree harvesting (WTH, removal of stems and logging residues), and WTH and stump harvesting (WTH+S). Both sites were also mounded. Soil samples were systematically collected from the three different soil disturbance surfaces (undisturbed soil, the mounds and the pits). Samples were incubated in the laboratory to determine the C and N mineralization rates (ug CO2-C g-1 C day -1 and mg N g-1 C day-1, respectively). In addition, total C and N pools (g m-2) were estimated for each disturbance class and soil layer. The sampling was performed 11-12 years after the logging treatments.

Stump harvesting increased soil mixing as indicated by a significant decrease in C concentration in the mounds. Soil C and N pools tended to be lower following stump harvesting, but no statistically significant treatment effect was detected. Furthermore, there was no significant effect of stump harvesting on soil C mineralization rates. Stump harvesting did not seem to have any stimulating effect on soil CO2 efflux.

stump harvest, bioenergy, forest soil, soil carbon

Theme 5: Forests, Soil and Water Interactions

131 - Exploring the contribution of the tree-soil metagenomes to forest resilience

KG I - 1009 (Uni Freiburg)

IUFRO17-285 **Soil microbiome biology for healthy forests: An introductory talk.**

Seguin, A.* (1)

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Abstract: The recent advent of the next generation DNA sequencing and related omics technologies has enabled detailed exploration of forest soil microbiome (i.e. the community of microorganisms such as bacteria and fungi), providing new capability to monitor soil health and define new indicators of soil quality based on biological and molecular data in combination with other approaches. These new tools in forest science can now be use to demonstrate forest ecosystem integrity and the sustainability of forest management practices. Those same tools will also be crucial to assess the direct and indirect impacts of climate change on taxonomic and functional diversity of the soil microbiome in order to forecast possible forest resilience.
There is an increasing body of literature showing major effects of forest soil health in maintaining appropriate carbon and nutrient cycling, soil respiration and water quality. New questions can now be investigated through forest soil microbiome such as: Are some microbial populations and their associated functions found in many habitats, regardless of the dominant tree species (conifers vs. hardwood species)? Do the same major soil microbial functional groups dominate similar habitats (e.g. wood debris, root tips) in different biomes (e.g., boreal vs. temperate), and can patterns be linked to the underlying geochemical conditions of environment?
This presentation will be an introduction on forest microbiomes with background information for the newcomers about the technical aspects related to this type of research and explanation of specific terms such as metabarcoding, metagenomics and metatranscriptomics. An overview of the recent breakthroughs in this field will also be presented.

metagenomics, soil microbiome, forest resilience

KG I - 1009 (Uni Freiburg)

IUFRO17-1788 **A decade of irrigation transforms the soil microbiome of a water-limited pine forest**

Hartmann, M.* (1); Brunner, I. (1); Hagedorn, F. (1); Frey, B. (1)

(1) Swiss Federal Research Institute WSL, Birmensdorf, Switzerland

Abstract: The impact of climate change on the soil microbiome potentially alters the biogeochemical cycle of terrestrial ecosystems. In semi-arid environments, water availability is a major constraint on biogeochemical cycles due to the combination of high summer temperatures and low rainfall. We explored how ten years of irrigation of a water-limited pine forest in the central European Alps altered the soil microbiome and associated ecosystem functioning. A decade of irrigation stimulated tree growth, resulting in higher crown cover, larger yearly increments of tree biomass, increased litter fall, and greater root biomass. Greater amounts of plant-derived inputs associated with increased primary production in the irrigated forest stands stimulated soil microbial activity coupled to pronounced shifts in the microbiome from largely oligotrophic to more copiotrophic lifestyles. Microbial groups benefitting from increased resource availabilities (litter, rhizodeposits) thrived under irrigation, leading to enhanced soil organic matter mineralization and carbon respired from irrigated soils. The loss of soil carbon due to increased microbial activity under irrigation was contrasted by higher primary production and enhanced carbon sequestration to the extent that it fully compensated for the increased soil organic matter decomposition. This unique long-term study provides new insights into the impact of precipitation changes on the soil microbiome and associated ecosystem functioning in a drought-prone pine forest ecosystem and improves our understanding of the persistency of long-term soil carbon stocks in a changing climate.

Forests, drought, soil microbiome, metagenomics

KG I - 1009 (Uni Freiburg)

IUFRO17-2051 **The phylogenetic and functional composition of forest soil ecosystems may be more susceptible to shifts in climate than land use**

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(1) Scion Research, Christchurch , New Zealand; (2) AgResearch Ltd, Lincoln Science Centre, Christchurch 8140, New Zealand; (3) Lincoln University, Faculty of Agriculture and Life Sciences, Christchurch, New Zealand

Abstract: The most visible effects of land use change are on animal and plant biodiversity, however there may also be impacts on the biodiversity of soil organisms, and potentially changes in ecosystem services provided by soils. In order to assess the effects of land use change in New Zealand, in different environmental settings, soil samples were collected from under native forest, plantation forest, and grazed pastures, at each of four different sites: Hokitika (high-rainfall, temperate), Craigieburn (subalpine climate), Eyrewell (low-land plains, seasonally dry), and Banks Peninsula (coastal, maritime). The phylogenetic (bacterial) and functional composition of the microbial communities were assessed using PhyloChip and GeoChip high-density microarray analysis of DNA extracted from the soils. Sample location was strongly linked to shifts in the phylogenetic (P=0.015) and functional composition (P=0.007). However, land use accounted for only a small amount of variation of bacterial taxa when comparing native forest and pastoral soils (P=0.022), and did not alter the functional composition of the soils among any of the land use comparisons (main effect P=0.636). As the sites embodied a diverse range of environmental conditions, the effects of climate on soil ecosystem within regions may be stronger than effects of land use change.

Theme 5: Forests, Soil and Water Interactions

131 - Exploring the contribution of the tree-soil metagenomes to forest resilience

KG I - 1009 (Uni Freiburg)

IUFRO17-2244 **Bringing a microbial dimension to the management of current and future forests**

Smaill, S.* (1); Addison, S. (2); Clinton, P. (1)

(1) Scion, Christchurch, New Zealand; (2) Scion, Rotorua, New Zealand

Abstract: The activity of the soil microbial community is fundamental to the health and productivity of planted forests. This influence is evident in the role of soil microbes in nutrient cycles and resource uptake, and extends to stress tolerance, immune response and the hormonal regulation of growth. Despite this importance, microbial interactions are largely not considered in conventional forest management. To address this gap, strategies to enhance the beneficial activity of ectomycorrhizal fungi in seedling nurseries were explored. Studies focusing on the opposite end of the forest lifecycle, employing molecular analysis prior to harvesting, were also conducted. Altering nursery chemical use supported more effective mycorrhizal activity, producing seedlings of greater quality that were more resilient and vigorous over several years' growth in the plantation. The end-of-rotation research determined that site establishment practices can promote changes in the ability of microbial communities to promote stress tolerance, fix nitrogen and produce phytohormones that persist for decades, with clear implications for the performance of current and future rotations. The results of these two projects provide new opportunities to develop more holistic management practices that make better use of microbial interactions to enhance the resilience and productivity of our planted forests.

soil microbes, growth promotion, forest management

Theme 5: Forests, Soil and Water Interactions

205 - Phloem function and dysfunction under drought

KG I - 1098 (Uni Freiburg)

IUFRO17-1391 **Long-term effects of repeated summer drought on phloem functionality in adult trees**

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(1) Ecophysiology of Plants, Technische Universität München, Freising, Germany

Abstract: Study objects are c. 60 to 70 year-old European beech and Norway spruce, readily accessible via scaffolding and canopy crane at Kranzberg Forest (southern Germany). Effects of repeated summer drought are assessed in an ongoing throughfall-exclusion experiment with roughly 100 trees assigned to a total of 12 plots (**K**ranzberg forest **ROOF** experiment, kroof.wzw.tum.de). The drought treatment started in 2014 with precipitation throughfall being completely excluded from early spring (March) to late fall (November). Drought stress caused distinct reductions in e.g. stem diameter growth, photosynthesis and pre-dawn leaf water potentials as low as -2.5 MPa.
We tested the hypothesis that long-term drought affects phloem morphology and functionality, e.g. speed of sugar transport. Allocation of recently fixed photoassimilates was studied by branch-bag labelling with 99 atom% $^{13}CO_2$. Mean residence time of ^{13}C label in the leaves was increased from 34.5 h under control conditions to 52.6 h under drought. The speed of phloem transport, however, appears unaffected with an average transport rate of 0.15 m/h. In addition, transport of photoassimilates along the branches and stems from the canopy to the base of the trunk (DBH) was assessed by natural abundance of delta ^{13}C and delta ^{18}O in sucrose. Under drought, mixing of recent photoassimilates with older C during phloem transport significantly affected isotopic signatures of transported sugars, distinctly diminishing the impact of drought. A quantitative relationship of this mixing effect (i.e. uncoupling of photosynthetic fractionation at the leaf level and isotopic signatures in stem cellulose) was established.

Drought, beech, spruce, sugar transport, tree ring

KG I - 1098 (Uni Freiburg)

IUFRO17-1733 **Effect of phloem transport disruption during lethal drought on plant carbon-source and sink activity.**

Salmon, Y.* (1); Lintunen, A. (2); Chan, T. (2); Vesala, T. (1); Hölttä, T. (2)

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Abstract: Recent studies have shown that the phloem is an underestimated actor in tree death during drought. The present experiment focuses on the effect of phloem transport disruption on tree source and sink activities. Under controlled conditions, we exposed seedlings of two angiosperms and two gymnosperms species to lethal drought. Needle water potential was measured with a pressure chamber to quantify the stress level the seedlings were under. We measured: 1) stem phloem response through changes in osmolality (as a proxy for soluble sugars) and turgor. Osmolality was measured using an osmometer. Relative turgor changes were measure using two point-dendrometers (measuring over living bark and xylem), and then calibrated against absolute values calculated from stem water potential and osmolality assuming water potential equilibrium between xylem and phloem; 2) leaf (source) response to drought through changes in gas-exchange, osmolality and starch content; and 3) sink activity through root respiration, root osmolality and starch content. Preliminary results showed that impairment of phloem transport leads to decreased leaf-gas exchange, primarily through an increase in non-stomatal limitation of photosynthesis due to accumulation of sugars in the leaf followed by stomatal closure. Our results suggest that disruption of phloem transport is likely a key mechanism to understanding tree mortality during drought.

tree, mortality, osmolality, respiration, stomata

KG I - 1098 (Uni Freiburg)

IUFRO17-1791 **13 CO2 pulse labelling experiment reveals phloem function impairment in young beech trees subjected to severe drought**

Desalme, D.* (1); Priault, P. (1); Dannoura, M. (2); Plain, C. (1); Angeli, N. (1); Massonnet, C. (1); Epron, D. (1)

(1) UMR Ecologie et Ecophysiologie Forestières, Université de Lorraine, Vandoeuvre les Nancy, France; (2) Laboratory of Forest Utilization, Kyoto , Japan

Abstract: Increasing frequency of drought-induced tree mortality was observed worldwide. Deciphering physiological dysfunctions leading to tree death is a major issue to better anticipate forest die-off episodes.

The fate of new photosynthates was investigated in 10-year-old beeches submitted to severe drought (soil water potential < -1.8 MPa) during one year. Whole crown $^{13}CO_2$ pulse-labellings were performed at the end of May 2015. Leaves and phloem were collected until 6 days after the labelling and ^{13}C contents were quantified in bulk tissues and specific compounds.

The fraction of total assimilated ^{13}C recovered in the fraction containing soluble sugars, amino acids, and organic acids decreased slower in leaves of drought trees compared to control, resulting in higher 13C mean residence time (> 40 hours versus < 1 day). Furthermore, higher concentrations of soluble sugars and amino acids were found in leaves of drought trees.

Little amount of ^{13}C was recovered in phloem extracts and in the CO_2 issued from the trunk respiration of drought trees, suggesting dysfunctions in phloem loading or transport. Carbohydrates transport may be affected by drought especially since a 2.5 fold higher phloem sap viscosity has been estimated. Specific-compound isotopic analysis of phloem extracts would clarify the impacts of severe drought on phloem function.

drought, phloem, 13C, Fagus sylvatica

Theme 5: Forests, Soil and Water Interactions

205 - Phloem function and dysfunction under drought

KG I - 1098 (Uni Freiburg)

IUFRO17-1624 **Differences in phloem anatomy alters its function under drought stress**

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(1) Kyoto University, Kyoto, Japan; (2) Universite de Lorraine, Nancy cedex, France

Abstract: Carbon transport failure under drought may lead to tree die, which is an important issue to predict the future of forest under climate change. The phloem has obviously an important role of photosynthate transport in trees. However, there is still a lack of knowledge because of difficulties of the observation and measurement of the phloem transport. In this study, our objective was to understand how observed differences in phloem anatomy affected its function under drought stress.
The study was conducted in a nursery on 9 year-old beech saplings in Lorraine, France. Two levels of drought stress were continuously applied for 2 years before the bark samples were taken from 3 trees of each treatment, including control, and immediately put into glutaraldehyde solution. The cross-section area of sieve tubes, the thickness of inner bark containing active sieve tubes and the sieve tube density were estimated using microphotographs of transversal section of bark.
The average size of sieve tube's section was smaller in trees under drought than in control. A 13C labeling experiment showed slower carbon transfer rates in the drought stress trees. We conclude that the differences in phloem anatomy accounted for higher resistance to the phloem transfer under drought.

anatomy, carbon transfer, drought stress, phloem

KG I - 1098 (Uni Freiburg)

IUFRO17-3067 **Phloem function and physiological mechanisms of sapling survival and mortality during drought**

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Abstract: Drought is expected to increase in frequency and severity in many biomes under global climate change. Hydraulic failure and carbon starvation are major hypotheses to explain drought-induced tree die-offs, but current understanding of the physiological mechanisms is incomplete and limits the ability to model the threshold events in destroying of forest ecosystems. Here we show the physiological responses to lethal drought along with tree wilting processes, including the thresholds of plant survival and mortality in two-year-old pioneer trees, Trema orientalis (L.) Blume. Following labeling 13C (stable carbon isotope), the healthy tree (leafy trees) represented the fast upward and downward translocation of carbon from one day later. On five days later, the amounts of translocated carbon at the stem bases were higher in the healthy tree than in the defoliated trees. The defoliated trees are corresponding to around the threshold of height growth and tree death, and their carbohydrate reserve in the stem bases increased, because of impeding phloem transport. The healthy trees exhibited high physiological activity, but relatively low carbohydrate reserve in the stem bases. With progressing defoliation, soil-to-leaf hydraulic conductance, respiration rates in distal branches and stem bases and leaf gas exchange rates decreased. Carbohydrate reserve within sapwood at the stem base had a peak before the thresholds of height growth and tree death. With more progressing of defoliation, carbohydrate reserve in the stem bases decreases again when trees die. The carbohydrate reserve is essential for maintaining hydraulic function and structural plant growth against dehydration stress, yet the depression of root hydraulics, cell metabolism and carbon-transport function in phloem triggers tree death.

drought mortality, water relations, xylem embolism

KG I - 1098 (Uni Freiburg)

IUFRO17-492 **Carbon allocation, drought and source-sink relationships in trees**

Gessler, A.* (1); Hagedorn, F. (1); Galiano, L. (1); Schaub, M. (1); Joseph, J. (1); Arend, M. (1); Robert Hommel, R. (2); Kayler, Z. (3)

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Abstract: Trees are large global stores of carbon that will be impacted by increased carbon dioxide levels and climate change. However, at present we cannot properly predict the carbon balance of forests in future as we lack knowledge on how plant physiological processes and especially the transfer of carbon within the plant interact with environmental drivers and ecosystem-scale processes. The central conveyor belt for C allocation and distribution within the tree is the phloem and its functionality under environmental stress (esp. drought) is important for the avoidance of C starvation.
This paper will address the distribution of new assimilates within the plant using 13C pulse labelling techniques. We provide experimental evidence that at least two mechanisms are employed by trees to couple sink processes to assimilation and a fast coupling is assumed to be induced by pressure concentration waves travelling through the phloem. Moreover, we relate phloem transport velocity of labelled 13C assimilates to drought stress intensity and discuss how source control might affect phloem transport in trees under drought and after drought release.

13C, pressure concentration waves, drought

Theme 5: Forests, Soil and Water Interactions

205 - Phloem function and dysfunction under drought

KG I - 1098 (Uni Freiburg)

IUFRO17-314 **Potassium nutrition and water availability affect phloem transport of photosynthetic carbon in eucalypt trees**

Epron, D.* (1); Cabral, O. (2); Laclau, J.-P. (3); Dannoura, M. (4); Parker, A. P. (2); Plain, C. (5); Moreira, M. (6); Nouvellon, Y. (3)

(1) Université de Lorraine, UMR INRA UL 1137, Vandoeuvre-les-Nancy, France; (2) Embrapa Meio Ambiente, Jaguariúna, Brazil; (3) CIRAD, UMR Eco&sols, Montpellier, France; (4) Kyoto University, Laboratory of Forest Utilization, Kyoto, Japan; (5) Université de Lorraine, UMR INRA UL 1137, VANDOEUVRE LES NANCY, France; (6) Universidade de São Paulo, CENA, Piracicaba, Brazil

Abstract: Potassium fertilisation strongly affects growth and carbon partitioning of eucalypt on tropical soil. In addition, potassium fertilization could be of great interest in mitigating the adverse consequences of drought in planted forests, as foliar K concentrations influence osmotic adjustment, stomatal regulation and phloem loading. But little is known about the effect of potassium nutrition on phloem transport and on the interaction between K nutrition and water availability.
In situ 13C pulse labelling was conducted on tropical eucalypt trees grown in a trial plantation with plots in which 37% of throughfall were excluded using home-made transparent gutters (-W) or not (+W) and plots that received 0.45 mol K m-2 (+K) or not (-K). Three trees were labelled in each of the four treatments (+K+W, +K-W, -K+W and -K-W), for one hour by injecting pure 13CO2 in a whole crown chamber. We estimated the velocity of carbon transfer in the trunk by comparing time lags between the uptake of 13CO2 and its recovery in trunk CO2 efflux recorded by off axis integrated cavity output spectroscopy in two chambers per tree, one just under the crown and one at the base of the trunk.
The velocity of carbon transfer in the trunk was twice as high in +K trees as in -K trees, with no significant effect of throughfall exclusion except for one tree exposed to a more pronounced water stress. Our results suggest that besides reductions in photosynthetic C supply and in C demand by sink organs, the lower velocity under K deficiency is due to a lower cross section area of the sieve tubes, while an increase in phloem sap viscosity is more likely limiting phloem transport under drought.

phloem, drought, Eucalyptus grandis, fertilization

KG I - 1098 (Uni Freiburg)

IUFRO17-1830 **Tree response to drought under changing climate regimes: mitigation or amelioration?**

Hubeau, M.* (1); Steppe, K. (1)

(1) Ghent University, Gent, Belgium

Abstract: A climate change treatment chamber experiment was conducted to assess how an important European tree species, *Populus tremula*, coped with a combination of elevated [CO_2] and temperature and how drought additionally affected growth performance. We grew 1-year potted *P. tremula* trees under ambient control conditions (400 ppm CO_2 and ambient temperature) and under predicted climate change conditions (700 ppm CO_2 and ambient +3°C). Half the trees in both treatment chambers were watered to a soil water content near field capacity, and half to about 70 % of this value. Both tree water and carbon relations were investigated. Sap flow and stem diameter changes were continuously measured with plant sensors. Vulnerability to drought-induced cavitation was examined with the acoustic emission technique. Treatment effects on phloem transport were investigated with positron emission tomography (PET), a medical technique that enables *in-vivo* and non-invasive measurement of sugar transport after labelling with radioactive $^{11}CO_2$. The plant-PET scans were used to develop mechanistic understanding on phloem transport speed and sugar exchange among treatments. This multidisciplinary approach is needed to understand the complex responses of trees under changing climate regimes, because surprisingly we observed that the drought-stressed trees under elevated conditions grew best.

water-carbon relations under a changing climate

KG I - 1098 (Uni Freiburg)

IUFRO17-1008 **Phloem sap as a diagnostic assessment of plant water and nutritional status**

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Abstract: Developing tools for the rapid assessment of plant health is of considerable interest for maximising growth and productivity of forest systems. Phloem is the central conduit for long distance transport and signalling in plants and offers great promise in reflecting plant scale resource limitations. Changes in the abundance of solutes and isotopes in phloem sap are sensitive to environmental cues. With a focus on both water and nutrient availability, we outline temporally and spatially integrative tools for the rapid assessment of plant water and nutritional status.

Phloem, isotope, nutrient, Eucalyptus

Theme 5: Forests, Soil and Water Interactions

123 - Roots and Ecosystem Services

KG I - 1015 (Uni Freiburg)

IUFRO17-3691 **Adaptive root foraging strategies along a boreal-temperate forest gradient**

Ostonen, I.* (1); Truu, M. (1); Helmisaari, H.-S. (2); Borken, W. (3); Vanguelova, E. (4); Godbold, D. (5); Tedersoo, L. (1); Lõhmus, K. (1); Truu, J. (1)

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Abstract: Tree root-mycorhizosphere plays a key role in resource uptake, but also in adaptation of forest to changing environments. We evaluated adaptive foraging mechanisms of ectomycorrhizal (EcM) and fine roots of Picea abies, Pinus sylvestris and Betula sp along a temperate to subarctic boreal forest gradient (38 sites between latitudes 48 ° N and 69° N) in Europe. We estimated the response of absorptive fine root biomass (EcM-FRB), root tissue density and %N, mycelia biomass in soil per root length unit (sEMM), changes in community structure of root-associated EcM fungi and rhizosphere bacteria in relation to climate, soil and stand characteristics.
We observed a significant increase of EcM-FRB per stand basal area towards boreal forests for all studied tree species, coinciding with longer and thinner root tips with higher root tissue density and decrease in sEMM. These changes were associated with a shift in community structure of dominating EcM fungi in coniferous forests as well as with lower number of bacterial phylotypes in the rhizosphere of fine roots in birch stands. Soil C:N ratio was a factor characterizing most of the variability in functional root traits and rhizosphere bacterial community structure. We suggest a conceptual multidimensional framework for adaptive foraging mechanisms of fine root involving both qualitative and quantitative changes in root-mycorhizosphere along climate and soil C:N gradients.

forests, root foraging, root-mycorhizosphere

KG I - 1015 (Uni Freiburg)

IUFRO17-2045 **Functional specialization of Eucalyptus grandis fine roots: contrasting potential uptake rates for nutrients in function of depth and soil fertility**

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Abstract: Little is still known about the role of deep roots in the nutrition of forest. We then studied the potential uptake of N, K and Ca by Eucalyptus grandis trees (2 years of age), in Brazil, as a function of soil depth and fertilization. Our hypotheses were: i) deep roots are more efficient than the shallow roots in potassium and calcium uptake compared to nitrogen ii) the specialization of the eucalyptus roots in nutrient absorption decreases when soil fertility is improved by fertilization. We injected NO3 -15N, Rb+ (analog of K+) and Sr 2+ (analog of Ca 2+) tracers simultaneously in a solution at 10, 50, 150 and 300 cm in depth. A complete randomized design was set up with three replicates of paired trees per injection depth and soil fertility. Recently expanded leaves were sampled at 70 days after tracer injection. Determination of foliar Rb, Sr concentrations and 15N atom% makes it possible to estimate the relative uptake potential (RUP) from the 4 soil depths and the Specific RUP, defined as RUP, per unit of fine root length density in the corresponding soil layer. The results being analysed will give insights into the functional specialization of roots in forests.

deep root, nutrient uptake potential,Eucalyptus

KG I - 1015 (Uni Freiburg)

IUFRO17-1430 **Root branching is a leading root trait of the plant economics spectrum in temperate trees**

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Abstract: Global vegetation models use conceived relationships between functional traits to simulate ecosystem responses to environmental change. Coordinated leaf trait variation is suggested by the leaf economics spectrum (LES), which separates species which invest into short-lived leaves with fast energy return from species with longer-lived leaves and slower return. While it has been assumed that being fast or slow is a general feature for all organs, the translation of the LES into a root economics spectrum (RES) for trees has been hitherto inconclusive. This may be partly due to the assumption that the bulk of tree fine roots have similar uptake functions as leaves, despite the heterogeneity of their environments and resources. In this study we investigated well-established functional leaf and stature traits as well as fine root traits (for different root orders) of 13 major temperate tree species of Central Europe, representing two phylogenetic groups (gymnosperms and angiosperms) and two mycorrhizal associations (arbuscular and ectomycorrhizal). We found reflected variation in leaf and lower-order root traits in some (surface areas and C:N) but not all (N content and longevity) traits central to the LES. Accordingly, the LES was not mirrored below-ground. We identified significant phylogenetic signal in morphological lower-order root traits. By contrast, root architecture was strongly influenced by the mycorrhizal association which developed independent from phylogeny of the host tree. In SEMs we show that root branching significantly influences both below-ground and above-ground traits which relate to resource investment and lifespan. We conclude that branching of lower order roots can be considered a leading root trait that relates to the mycorrhizal association type and below-ground resource acquisition; while the dominance of the phylogenetic signal makes morphological root traits less suitable for describing economics spectra among temperate tree species.

functional traits, mycorrhiza, root order

Theme 5: Forests, Soil and Water Interactions

123 - Roots and Ecosystem Services

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IUFRO17-1820 **Variation of root anatomical traits: from tropical forests to deserts**

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Abstract: Root functional traits have been effectively used to predict plant belowground resource acquisition strategies, which are key for community structure and ecosystem functioning. Many root morphological and physiological traits commonly used in trait studies are results of root anatomy. Thus a better understanding of root anatomy can reveal previously unrecognized mechanisms of root morphological and physiological responses to environmental conditions. In this study, we analyzed anatomical traits of the absorptive first-order roots across 191 species sampled from tropical forests, temperate forests, grasslands and deserts. The absolute sizes and the ratio of root stele and cortex show marked differences across plant functional types, with thin-cortex herbaceous plants having higher proportion of stele than thick-cortex woody plants. Fewer and larger vessels, together with thinner cortex allow desert herbaceous species to quickly exploit transient pulses of water. By contrast, denser and smaller vessels, along with thicker cortex can improve the efficiency of ion exchange and enhance protective functions in tropical woody plants. Moreover, root stele displayed narrower variation than diameter (and cortex) across biomes, indicating conservatism in basic root hydraulic design. Our results suggest that plant can acclimate to changing environmental conditions by modifying cortex-ion-absorption and stele-water-transport functions depending on the primary limiting resource supply and dominant stress factors.

root stele, cortex, hydraulic traits, diameter

KG I - 1015 (Uni Freiburg)

IUFRO17-1102 **Fine-root morphological traits in tropical forest ecosystems in relation to rainfall and temperature**

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Abstract: Root traits, including specific root length (SRL-root length per unit dry mass), specific root area (SRA-root surface area per dry mass), and root tissue density (RTD-root dry mass per volume) are regarded as important indicators of environmental changes. Here, we compiled 69 observations from forests across the tropics, and used regression analysis to determine patterns in fine-root SRL, SRA and RTD in relation to annual rainfall and mean annual temperature (MAT).

We observed differential responses in traits to annual rainfall and MAT. Annual rainfall and MAT explained < 2 % of the variations in SRL and SRA across the tropics. Mean annual temperature was the most significant factor, explaining 69 % of the variance in RTD. When the data were separated into Paleotropical (Africa and Asia) and Neotropical (Central and South America) forests, all the traits declined with increasing MAT, RTD and SRL declined with increasing annual rainfall in the Paleotropics, and RTD increased with MAT in the Neotropics.

The results suggest that rainfall and MAT influence RTD, but not SRL and SRA. However, the response of root traits to climate may differ among regions. This has implications for resource acquisition and C dynamics of forests in tropical regions.

Root traits, specific root length, tropical forest

KG I - 1015 (Uni Freiburg)

IUFRO17-3764 **Belowground-aboveground relationships: responses to forest management**

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Abstract: This abstract is based on a review with the aim to discuss the forest management impacts on roots and mycorrhizas and their relationships with the aboveground.
Roots with their mycorrhizas have an important role in carbon and nutrient cycling (nutrient uptake from soil, carbon and nutrient use for growth and maintenance, return to soil in litter and partial release in decomposition), and recent reports show their role in weathering and in mobilization of organic nitrogen.
Forest management generally aims to increase the aboveground biomass production for greater harvests while belowground responses have received less attention. Aboveground production of Scots pines was recently shown to increase as a result of reduced carbon partitioning belowground in nitrogen-fertilized stands (Lim et al. 2015). Also, mycelia growth was reported to reduce in intensively fertilized Norway spruce forests while aboveground growth increased (Wallander et al. 2011). Increased aboveground production may not, however, result into increased soil carbon stores (Crow et al. 2009) as fine root litter may enhance soil carbon sequestration more than litter from the aboveground (Hu et al. 2016).
The belowground and aboveground parts of woody plants are tightly linked and a whole-tree approach is needed for understanding tree productivity under different management.

biomass, carbon, nutrients, production, roots

Theme 5: Forests, Soil and Water Interactions

66 - Water Related Ecosystems Services under Risk

K9 (Konzerthaus Freiburg)

IUFRO17-1971 **Patterns of ecosystem restoration in geographically-isolated forested wetlands following hydrologic recovery**

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Abstract: This study examined the potential for restoration of ecosystem services from geographically isolated forested wetlands at Starkey Wilderness Park (SWP), in New Port Richie, Florida, USA. As a municipal wellfield, SWP has a history of hydrologic alterations. Groundwater withdrawal for municipal water supplies began in the mid-1970's and steadily increased up to 11 million gallons per day by 2007. Continuous pumping was shown to impact many surface water features in the SWP including forested wetlands. However, after 2007, alternate water supplies were secured and groundwater withdrawals were reduced by nearly 75%. As part of current research and ongoing monitoring efforts, detailed hydrologic, edaphic, and vegetative data were collected in over 27 isolated cypress swamps throughout the SWP. We compared vegetation communities before and after pumping reductions to assess potential vegetation responses. All wetlands were isolated cypress swamps that were categorized based on the extent of past hydrologic alteration (reference, marginally affected and highly affected). Results showed that all wetlands responded to hydrologic recovery with greater understory richness however only the marginally affected wetlands were on a trajectory to becoming comparable with reference conditions. Wetland conditions related to soil organic content and past subsidence appear to be important factors driving wetland response to hydrologic recovery. We compare these results with recent efforts to assess soil processes in the same wetlands in order to determine important thresholds and indicators for overall ecosystem restoration.

forested wetlands, restoration, ecosystem services

K9 (Konzerthaus Freiburg)

IUFRO17-1508 **Climate Change induced Risk to Freshwater Forested Wetlands along the Apalachicola Bay, USA**

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Abstract: Tidal freshwater forested wetlands provide important and diverse ecological and socioeconomic services. Because they are commonly found within the tidal reach of large rivers, these systems are highly sensitive to fluctuations in sea level, freshwater input related to climate change and river management. This study focuses on the hydrologic conditions, salinity fluctuations, and corresponding forest communities along a tidal gradient at two distributary rivers (St Mark's and East River) of the Apalachicola River in northwest Florida, USA. Twenty-two forest plots were surveyed (11 on each river) to assess changes in forest composition along a tidal gradient. Water level and salinity were monitored at six of these sites for a year to develop salinity prediction models. An Artificial Neural Network based model was developed to predict historical salinity fluctuations along the lower distributary rivers and relate them to wetland species assemblages. Scenarios were developed under varying river discharge and tide levels to scrutinize the potential changes in forested vegetation along the St. Mark's and East River that could occur under varying climate and river management scenarios. Results show that sea level rise associated with reduced freshwater discharge can result in significant changes in the vegetation communities in the study region.

climate change, forested wetland, salinity, ANN

K9 (Konzerthaus Freiburg)

IUFRO17-2371 **Use of LANDSAT 8 OLI, ALOS-PALSAR L-HH and L-HV, DEM and slope data for wetland mapping in southern New Brunswick**

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Abstract: This study used the Random Forest classifier to classify LANDSAT-8 OLI, ALOS-PALSAR L-HH and L-HV SAR, a digital elevation model (DEM) and slope data for mapping wetland areas in southern New Brunswick. The images were acquired both at high and low water levels in the wetlands. Adding SAR images in the classifier improves the classification accuracy. By comparison with GPS field data, the resulting classified image allows the identification of a higher number of wetlands than the two current wetland maps currently in use by the Province of New Brunswick, namely the Department of Natural Resources (DNR) wetland and forested wetland maps. Indeed, SAR images allow detecting wet areas below the forested cover, while the DNR maps were created by photo-interpretation of aerial photographs. For the classified image, the few mis-classifications are due to wetland sites classified in another wetland class. For the DNR maps, about half of them are associated to wetland sites that not being mapped, the remaining half being wetland sites that are not classified in the right wetland class. The study was funded by a grant from the Eastern Habitat Joint Venture program of Environment Canada

Wetland mapping, Satellite images, Remote sensing

Theme 5: Forests, Soil and Water Interactions

66 - Water Related Ecosystems Services under Risk

K9 (Konzerthaus Freiburg)

IUFRO17-3538 **A holistic assesement of water related ecosystem services in urban forests**

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Abstract: Urban trees and forested areas have a great water retention potential since they are enhancing evapotranspiration and water infiltration into the soil as well as regulating the amount of throughfall reaching the ground. This study provides a holistic methodological framework for assesing water related ecosystem services in urban forests. We propose and test a combination of indicators, related to canopy interception, topsoil water infiltration and soil water holding capacity in urban forests which differ in stand structure and soil properties. We standardized the obtained values on a relative scale: from 0 - no relevant potential; to 100 - maximum possible potential of urban forests under study for water retention.
The study occurred over a six-year period in an urban transect from the mixed forest in the city center towards a riparian pine forest and a floodplain hardwood forest. Canopy interception was calculated as a difference between measured open field precipitation and net precipitation (sum of throughfall and stemflow). Stemflow was estimated from a review of relevant literature. The selected indicator for soil water infiltration was the non-saturated hydraulic conductivity, which was measured using the Mini Disk Infiltrometer (Decagon Dervices Inc.). The selected indicator for soil water holding capacity was field capacity of the mineral soil, which was calculated from pressure plate measurements of soil moisture content at 0.33 bars, using representative soil samples.
The highest provison of water retention service was shown for mixed forest in the city center (80 scores), followed by floodplain hardwood forest (63 scores) and riparian pine forest (39 scores). The lowest provison of water retention service was indicated for urban grassland (22 scores).
Using natural urban forests to improve the provison of water related ecosystem services in urbanized watershed represents a nature based solution and could be incorporated in urban management and planning.

canopy interception, stand structure, soil

K9 (Konzerthaus Freiburg)

IUFRO17-930 **An Approach for Quantifying and Mapping Hydrological Ecosystem Services as a Watershed Management Tool**

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(1) Istanbul University, Istanbul, Turkey

Abstract: Ecosystems have curative effects on human well-being by providing benefits and services. However, rapid population growth around the world causes an unbounded utilization and loss of ecosystem services. Therefore, the ecosystem service concept has been prominent issue in the context of sustainable management for decision-makers and implementers to prioritize the land over the last decade. Identification and quantification of ecosystem services have an important role in this process. Additionally, this can be different for the hydrological ecosystem services when compared to other services due to dependence on watersheds' attributes. In other words, hydrological ecosystem services are related to the drivers that affect the routing of water through the watershed. In this study, it's aimed to quantify the water quality regulation service and obtain maps that show the capacity of watershed to provide it. Kagithane watershed, which is located in the European side of Istanbul, was selected as the study site. Coefficients between land use types and selected physical water quality parameters were estimated by a mathematical equation according to field data in sub-watershed scale. Thus, capacity of sub-watersheds for providing water quality regulation service was determined and mapped by a simple scoring method. Results of this study showed that some sub-watersheds with high forest cover rates had high capacity to provide water quality regulation service whereas some with multiple land use had low capacity. Moreover, the results revealed that land use in a watershed can improve or degrade the capacity of implemented service. Hence, prioritizing a watershed should be evaluated in terms of determining the highest capacity of any services in that watershed.

Ecosystem services, Watershed management, Land use

K9 (Konzerthaus Freiburg)

IUFRO17-1196 **Efficiency of water protection methods in forestry operations in the Baltic Sea Region**

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Abstract: Boreal and temperate forests cover 48% of the terrestrial part of the Baltic Sea (BS) drainage basin. Most of the forests are managed and they have a high economic value especially in the northern BS region countries. Rivers and streams transport nutrients and sediments to the water bodies. The forest management activities, primarily harvesting and forest drainage increase element loads to the receiving water bodies where they may cause eutrophication, siltation, sedimentation and decrease biodiversity. By leaving forested riparian zones between harvesting areas and by using various water protection methods such as sedimentation ponds, peak runoff control, infiltration areas and constructed wetlands, excess element loads to the water bodies can be reduced.

We carried out a literature review in the BS Region on the existing scientific knowledge of the efficiency of the riparian zones and different water protection methods used in forest drainage operation in reducing the leaching of nutrients and sediments to the water bodies. We found out that the efficiency of the riparian zones and different water protection structures varied from 100% retention to a considerable increase in leaching, depending on the element, site characteristics and the type and size of the water protection structure. We discuss the challenges, which are faced when comparing these results with existing guidelines for water protection in forestry operations.

Our presentation is prepared by WAMBAF (Water Management in Baltic Forests) project, which was initiated to tackle problems concerning forestry activities in relation to water quality funded by the EU Baltic Sea Region Programme during 2016-2019.

drainage, harvesting, riparian zone, water quality

Theme 5: Forests, Soil and Water Interactions

167 - Ecosystems, climate change and hydrology

K9 (Konzerthaus Freiburg)

IUFRO17-387 **Water consumption comparison of sample trees with dfferent DBH in the same stand**

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Abstract: One of the ecosystem services that forests provide is freshwater supply for society interms of not only water quality but also water yield. Turkey has a growing population, and the risk of facing with water shortages is quite high in near future according to statistics. Therefore, forest covers require a special management strategy to save water in the forested watersheds since forest cover consume enormous amount of water through transpiration. In this context, the water consumption of trees with different DBH (diameter at breast height) becomes important in terms of watershed management treatments in the forested watersheds serving as a fresh water producer. The aim of this study was to examine the water consumption of Anatolian black pine [Pinus nigra Arn. subsp. pallasiana (Lamb.) Holmboe] and sessile oak [Quercus patraea (Matt.) Liebl.] trees with different DBH. Six trees were chosen from stand of each tree species to represent different DBH's according to quantil of total method. The study period covered the growing season of 2016, and the study was carried out in Belgrad Forest, Istanbul. Both stands were pure, pine stand was planted while the oak was natural. Water consumption of the trees measured by tissue heat balance method. Mean air temperature, humidity, and precipitation were 17,4 ° C, 76.6 (%) and 341 mm respectively, during the study period. Results showed that the water consumption differs according to DBH, from 22 to 85 kg in oak stand, and from 10 to 54 kg in pine stand in daily average basis. The correlation between DBH and transpiration were similar and high for both stands (r=0,90 for pine and 0,91 for oak). It is also revealed that DBH of the trees should be taken into account for watershed management treatments in terms of water conservation and planning in these watersheds.

water consumption, dbh class, tissue heat balance

Theme 5: Forests, Soil and Water Interactions

123 - Roots and Ecosystem Services

KG I - 1015 (Uni Freiburg)

IUFRO17-980 **Do residual roots and stumps mitigate mineral soil carbon loss?: An examination of harvesting and organic matter removal experiments across a range of forest types**

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Abstract: Although soil carbon is known to hold at least two times as much carbon as that held in the atmosphere, the source and fate of soil carbon remains loosely understood. Managed forest soils in particular are subject to shifts in carbon inputs and state factor that regulate carbon stability (i.e. temperature and moisture). The goal of this study is to determine the importance of aboveground and belowground harvest residuals in mitigating soil carbon shifts following conventional harvesting techniques. We will report on a couple of case studies that have found a resilience to change in the soil carbon pool after extreme organic matter removal. In these case studies we have found that soil carbon pools tend to remain stable or increase immediately post-harvest even when there is little aboveground residuals left on site. Using C:N, stable isotopes, and biomarkers from whole soils and density fractions we have found that this increase in soil carbon appears to be derived from an input of root carbon. We will examine the ubiquity of this response across a range of forest types by performing a meta-analysis utilizing published carbon and C:N data from other organic matter removal experiments (e.g. Long-Term Soil Productivity experiments). We will explore the controls of climate, parent materials, texture, forest-type, and other factors on the response of soil C and C:N to conventional and extreme organic matter removal and harvesting treatments.

soil carbon, roots, harvest residuals, LTSP

KG I - 1015 (Uni Freiburg)

IUFRO17-1308 **Fine root dynamics and their contribution to net primary production in cool-temperate forests**

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Abstract: Fine roots are one of the major contributors to carbon and nutrient cycling in the forest ecosystems. We have investigated fine root biomass and production and estimated net primary production (NPP) in deciduous and coniferous forests dominated by such tree genera as *Quercus*, *Carpinus*, *Abies*, *Pinus*, and *Chamaecyparis* in Korea and Japan since 2011. To investigate fine root dynamics, we used ingrowth cores until 2013 and then we combined that technique with sequential soil cores and the flat-bed scanner method from 2014. NPP was calculated by sum of changes in biomass of aboveground organs and coarse roots as well as amounts of annual litterfall mass and annual fine root production. According to our results, up to 2013 annual litterfall mass was significantly different among the stands, while fine root production did not statistically differ among the stands. The average fine root turnover rate was 1.81 across forests. Litterfall and fine roots are major carbon sinks (34% for litterfall and 25% for fine roots of NPP, on average) across deciduous and coniferous forests in this study. Fine root production constituted 18-44% of NPP and belowground production was a greater fraction of NPP in more productive forests, suggesting their greater carbon allocation belowground. With more estimates of litterfall and fine root production measured by two added techniques from 2014, we can increase our understanding of the contribution of litterfall and fine root to nutrient dynamics in ecosystem processes.

root production, litterfall, ingrowth core method

KG I - 1015 (Uni Freiburg)

IUFRO17-2985 **Are tree species diversity and identity effects on soil carbon stocks linked with fine root biomass across Europe?**

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(1) Universiy of Copenhagen, Dep. of Geosciences and Natural Resource Management, Frederiksberg C, Denmark; (2) University of Leipzig, Institute of Biology, Leipzig, Germany; (3) Natural Resources Institute Finland -Luke, Joensuu, Finland

Abstract: Studies of functional species diversity have reported positive effects for aboveground carbon (C) sequestration, but the question remains whether higher soil C stocks could result from belowground niche differentiation driven by more efficient root exploitation of soils. We studied soil C stocks and fine root biomass in tree species diversity gradients in major European forest types in Finland, Poland, Germany, Romania, Spain and Italy within the FunDivEurope project.
We found consistent but modest effects of species diversity on total soil C stocks (forest floor and 0-20 cm) across the regions. Carbon stocks in the forest floor alone and in the combined forest floor and mineral soil layers increased with tree species diversity, but there was no similar general effect on on fine root biomass of trees or ground vegetation. In contrast, there was a strong effect of species identity on soil C and root biomass and root distribution. Within the Polish forest type we sampled soils to 40 cm and found that identity of the five tree species was again the main factor explaining forest floor and total soil C stock. However, species diversity increased soil C stocks in deeper soil layers (20-40 cm), while species identity influenced C stocks within forest floors. Root biomass increased with diversity in 30-40 cm depth, and a positive relationship between C stock and root biomass in the 30-40 cm layer suggested that belowground niche complementarity could be driving higher root C input and deeper distribution of C in diverse forests.
We conclude that total C stocks are mainly driven by tree species identity. Modest positive diversity effects were detected at the European scale with associated root biomass effect, while stronger positive effects on subsoil C stocks in Poland were associated with higher subsoil root biomass. Targeted selection of tree species would be a stronger management approach for soil C sequestration than increasing tree species diversity per se.

tree species, species diversity, SOC, fine roots

Theme 5: Forests, Soil and Water Interactions

123 - Roots and Ecosystem Services

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IUFRO17-4076 **Including below-ground tree biomass in quantification of carbon pools before and after variable retention harvesting in the mixedwood boreal forest**

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(1) University of Alberta, Edmonton, Canada

Abstract: Carbon stocked in below-ground tree biomass becomes relatively more important following forest harvest but, to this day, remains difficult to quantify with reasonable accuracy. Availability of allometric equations for below-ground biomass is limited and accuracy of root-to-shoot ratio is questionable. Furthermore, below-ground tree biomass decay is not well understood. In this study, we use destructive sampling to develop allometric equations to quantify above- and below-ground biomass for three tree species (Populus tremuloides, Populus balsamifera and Picea glauca) including regeneration and seven shrub species of the boreal mixedwood forest. We compare our below-ground biomass values to two root-to-shoot ratio methods applicable in our study area. We then combine our below-ground allometric equations with random root biomass sampling and root decay rate assessment to incorporate below ground biomass into a global ecosystem carbon pool quantification before and after variable retention harvesting in a broad scale fully replicated forestry experiment (Ecosystem Management Emulating Disturbance, (EMEND)). We found that the root-to-shoot ratio method developed by the Intergovernmental Panel on Climate Change produce reasonable estimates of below-ground tree biomass but some biases are introduced because of the dependence of root-to-shoot ration on tree size. The below-ground tree biomass represented about fifteen percent of the total carbon before harvest depending on the cover-type and above 20% in the most intense post-harvest treatments. Root wood density generally decreases faster than that of snags and logs.

Allometric, root-to-shoot ratio, root decay

KG I - 1015 (Uni Freiburg)

IUFRO17-1178 **Estimates of roots using ground penetrating radar and root anchorage in a coastal Pinus thubergii forest**

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Abstract: Pinus thunbergii have been widely distributed as coastal forests in Japan. However, very few information are available on root anchorage of P. thunbergii. The aims of this study were to i) clarify the root anchorage of P. thunbergii with different ground water tables and ii) determine the relationships with root system ground penetrating radar (GPR). Two experimental plots: sea-side (lower water table) and land-side (higher water table) in a coastal P. thunbergii forest with sandy soils were established. The tree pulling tests were conducted total 41 trees with mean diameter at breast height (DBH) was 15 cm in both plots and determined critical turning moments. Root systems of 29 trees were estimated using 900 MHz GPR with 25 cm interval circular transects. As the results, the critical tuning moments at land-side were higher than those at the sea-side plots, when the DBH was larger than 15 cm. Horizontal root systems in most trees were successfully detected using GPR. However, we did not observe significant relationships between root anchorages and the number of estimated horizontal roots. We conclude that not only horizontal roots but also vertical roots and root system structure should be clarified to estimate root anchorages.

Root-soil plate, Tree pulling test, Tsunami,

KG I - 1015 (Uni Freiburg)

IUFRO17-1177 **Root growth dynamics of three beech (Fagus sylvatica L.) provenances**

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Abstract: European beech (*Fagus sylvatica* L.) is a commercially and ecologically important tree species in Central European forests but its intraspecific variability in drought and temperature tolerance might endanger its future distribution in Europe. Beech phenological and growth traits have been studied in largescale international beech provenance trials, yet the growth and turnover of its fine roots (FR) has not been included among the observations. FR growth dynamics of three beech provenances in the international beech provenance trial Straza / Kamenski hrib, established in Slovenia in 1998, and in a natural beech regeneration site growing at its border, were studied from 2007 to 2010. We studied FR biomass using soil cores (SC), root production using ingrowth soil cores (IC), and root longevity using minirhizotrons (MR).FR biomass differed between two of the three tested provenances in the trial and in the natural regeneration site. Values of specific root length (SRL) in IC varied significantly among sampling periods, except for the natural regeneration. The turnover rates in IC were at the end of the experiment close to those measured with MR. Median MR-based longevities of fine roots varied between 625 and 934 days. The root survival curve of the provenance with slowest aboveground growth was significantly different from the other two provenances which lived longer. Death of FR, older than two years, occurred most likely in the winter. Our results suggest that there are significant differences in FR longevity among provenances, which might contribute to their adaptation to future environmental conditions. Furthermore, the calculated annual C investment into FR growth per ha differs up to twofold between provenances, contributing to different C dynamics of their future stands.

beech, provenance, adaptation, fine roots

Theme 5: Forests, Soil and Water Interactions

76 - Understanding the Forest-Water Nexus: Monitoring Tool

K 1 (Konzerthaus Freiburg)

IUFRO17-3705 **Long-term soil solution monitoring in temperate and boreal forests under the International Co-operative Programme on Forests**

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Abstract: Soil solution is the matrix by which all dissolved nutrients as well as toxic compounds pass from the soil to tree roots and represents a key indicator of the effects of air pollution and other stress factors on forest health. Soil solution has been monitored using harmonised methods by the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) for more than 20 years. The value of harmonised soil solution measurements and studies at the European scale compared to national approaches is that it facilitates the evaluation of continental scale drivers of environmental change and their interaction with regional and local conditions.
These data have been used to assess critical load exceedance as well as temporal and spatial patterns in solute concentrations (nutrients, harmful elements and dissolved organic carbon (DOC)) and their relationship with environmental stress factors. In addition, soil solution composition, together with estimation of soil water fluxes, has been used to calculate nitrate fluxes through the soil.
In this presentation we will summarize only the recent European-wide evaluations of ICP Forests soil solution data, since it is not possible to include all of the multiple approaches carried out so far. By providing continuous new knowledge of the interactions between soil water and other ecological parameters measured in the Programme, the ICP Forests soil solution monitoring constantly extends our understanding of temporal dynamics of forest-soil-water relationships under environmental change.

acidification, ICP Forests, DOC, long-term trends

K 1 (Konzerthaus Freiburg)

IUFRO17-3280 **Methods and tools to assess impacts of climate change on the role of trees and forests in the hydrological cycle**

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Abstract: The world experiences extreme weather events such as floods, droughts and increased frequency and intensity of dry spells. This will have a potentially devastating impact on the role of trees and forests in hydrological cycle and other environmental services worldwide. It is becoming increasingly evident that a pattern of growth, water use efficiency, and survivorship of tree species are sensitive to climate variations and stress induced mortality is prevalent. Especially in the tropics there is a substantial gap in fundamental knowledge concerning how tree species grow in response to climate variability, and therefore how they might react to future climatic change. This is particularly critical when restoration of forests and degraded landscapes is being at a higher global political concern to address challenges related to water and food security in a changing world. Our approach considers large scale climate gradients and different temporal scales (inter-annual and intra-annual variations) and combines multi- parameter measurements. During this presentation we will present methods and tools including tree ring analysis, carbon and oxygen isotopes to measure hydro climatic records, impact of atmospheric CO2 concentration in water use efficiency of trees and forests and its implication in the hydrological cycle, characterize drought tolerance, water use strategy and sources of water, based on our research activities in Africa and Asia, and suggest future research needs to enhance our understanding of the complex relationships between trees/forests and water at different temporal and spatial scale.

Dendro-isotopes, restoration, water use, tropics

K 1 (Konzerthaus Freiburg)

IUFRO17-3234 **Evaluating the Economic Value of Water Conservation by Forests: Evidences from Taiwan**

Liu, W. (1); Hsien, C.-H.* (1)

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Abstract: Water is the subsistence of human beings and it can be conserved by forests. With the continued consumption of natural resources, the problem of water scarcity has been becoming important. Estimating the value of water conservation becomes critical to investigate the sustainable use of water resources by forest. However, estimating the value of water is difficult. The estimates are easily affected by many factors, such as climate, topography, and data sources. Therefore, it is challenging to estimate the value of water accurately in a practical way. In this study, a water balance model with replacement cost is adopted to estimate the value of water conservation in eight national forest districts in Taiwan. The estimated water conserved in the national forest districts is approximately 24,845.12 million m3 annually and the average cost for reservoirs is NT$ 0.11/m3. The economic value of the water stored in Taiwan's national forest districts is estimated to be NT$ 2,765.17 million per year. The result of this study indicates that the capability of conserving water by forests conforms to rainfalls generally. In addition, the discounted cost of each reservoir in Taiwan has large variations in the assessment process. This study also suggests that we should consider water sources, in addition to the data scale, to improve the estimation accuracy.

ecosystem service,water conservation

Theme 5: Forests, Soil and Water Interactions

76 - Understanding the Forest-Water Nexus: Monitoring Tool

K 1 (Konzerthaus Freiburg)

IUFRO17-1725 **Understanding the Forest-Water Nexus: a monitoring tool**

Springgay, E.* (1)

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Abstract: Since the Shiga Declaration on Forests and Water in 2002, the forest-water topic has gained recognition in international fora. The theme has been featured and discussed in over 15 meetings and events, including the World Forestry Congress in 2015, ultimately with similar recommendations: improved knowledge and capacity, and integrated forest-water policy and practice. In response to the recommendations to improve monitoring and evaluation of forest-water interactions and to enhance our understanding of complex forests and water relationships, the FAO Forest and Water Programme initiated a process to develop a forest-water monitoring tool. Starting in 2016, this process began with a survey to take stock of the indicators, variable and methods, followed by a peer review and an expert workshop. The main objective was to develop an interactive monitoring tool with standardized indicators and recommended methodologies. If widely adopted, the tool will:
1. improve our understanding of forest-water relationships in different contexts;
2. generate comparable data that, in time, can be aggregated at national, regional and global levels;
3. support national forest monitoring assessments;
4. address knowledge gaps and identify opportunities for further understanding;
5. contribute to the enhancement of integrated forest-water practices and policies.
The status of the monitoring framework development process, as well as a review of the process and lessons learned will be shared.

K 1 (Konzerthaus Freiburg)

IUFRO17-3606 **Session overview**

Harper, R.* (1)

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Abstract: The 2015 United Nations Framework Convention on Climate Change meeting in Paris (CoP 21) resulted in several key decisions that will affect forests, and thus water and soils. The outcomes included emissions targets, with over 90 countries including land-based mitigation activities in their national targets (NDCs), clear interest in valuing the co-benefits of mitigation and considerably more interest from business interests. CoP 21 gave greater certainty to a range of activities that have been used to mitigate carbon emissions including programs to reduce deforestation (e.g. REDD+), increase reforestation or afforestation or avoid fossil fuel emissions via bioenergy or using wood products. It is expected that the impacts of this agreement on forests, and thus water and soils will be profound. In particular there are likely to be direct impacts of different mitigation activities on water yield, soil conservation and other agenda, including the UN Sustainable Development Goals and other UN Conventions. This session, sponsored by the IUFRO Taskforce on Forests, Water and Soils, will explore the implications of the CoP 21 meeting outcomes on forests, water and soils. This paper will introduce the session.

mitigation, policy, carbon, forests, soils, water

K 1 (Konzerthaus Freiburg)

IUFRO17-3652 **Prediction versus reality: the challenges in estimating below-ground forest carbon**

Sochacki, S.* (1)

(1) Murdoch University, Murdoch, Australia

Abstract: A key outcome of the 21st Conference of the Parties (COP21) meeting of the United Nations Framework Convention on Climate Change (UNFCCC) was the recognition of forest protection, management and restoration as key climate change mitigation strategies. This will result in a "global carbon stocktake" beginning in 2023 and every five years thereafter.
Given that more than 90 countries have identified forestry within their Nationally Determined Contributions (NDC), the ability to estimate carbon stocks in existing forest sinks and new reforestation projects will be a key challenge for this global stocktake. Carbon accounting systems are not in place for many agroforestry-reforestation systems and there are considerable associated challenges in estimating forest carbon in existing forests, in particular, below ground carbon. The reduced emissions from REDD+ initiatives will be as important as increases in forest carbon stocks through reforestation and forest management.
A key question is whether capabilities exist to adequately account for the carbon in roots, particularly where there may be a preference to rely on remote sensing approaches. This paper provides an overview of what is required to adequately measure root carbon in the major forest mitigation activities.

Theme 5: Forests, Soil and Water Interactions

28 - Implications of Global Climate Change Policies on Forests, Water and Soils

K 1 (Konzerthaus Freiburg)

IUFRO17-3621 **The Blue Targeting – designing a functional forest riparian zone**

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Abstract: Peatlands are a major store of carbon. Drainage and fire, often associated with agriculture and forestry conversion, results in global greenhouse gas emissions of around 1.3 Gt CO2-e/yr. While the broad principles of peatland carbon mitigation are known, reliable tools are needed to implement activities at scale and ensure permanence. Broad approaches involve (a) the protection of existing carbon stock in peat lands, and (b) the restoration of carbon stock in drained wetlands for example through rewetting, considered to be an efficient way of restoring wetland hydrology and reducing the greenhouse gas emissions. However, both involve either the loss of other income sources or new capital costs.

Carbon trading schemes have successfully developed methodologies for other types of forested land, such that carbon mitigation can be considered a forest product and provide an alternative income source. In this paper we examine the prospects for voluntary carbon trading to drive either the protection of peatlands or the rewetting of degraded peatlands, citing existing methodologies and regional offsetting schemes where mitigation tools are in use.

Protection of existing peatland carbon stocks has a precedence with avoided emissions from deforestation and could provide an income source to landholders. For rewetting drained peatlands, financing is needed to compensate income loss. For both approaches, we describe the economic and social co-benefits and tradeoffs of peatland carbon stock restoration.

Carbon trade, GHG, rewetting, drained peatland,

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123 - Roots and Ecosystem Services

KG I - 1015 (Uni Freiburg)

IUFRO17-85 **Responses of tree roots to drought and its effects on belowground carbon sequestration**

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(1) Swiss Federal Research Institute WSL , Birmensdorf, Switzerland

Abstract: The currently ongoing climate change is characterised by increased temperatures and altered precipitation patterns. Alongside, there has been an increase in both the frequency and intensity of extreme climatic events such as drought. Episodes of drought induce a series of interconnected effects, all of which have the potential to alter the carbon balance of forest ecosystems profoundly at different scales of plant organisation and ecosystem functioning. During recent years, considerable progress has been made in the understanding of how above-ground parts of trees respond to drought and how these responses affect carbon assimilation. In contrast, processes of below-ground parts are relatively underrepresented in research on climate change.

Tree roots are capable of responding to drought through a variety of strategies that enable them to avoid and tolerate stress. Responses include root biomass adjustments, anatomical alterations, and physiological acclimations. In addition, mycorrhizas seem to play an important protective role.

In order to investigate the influence of a dry and a moist environment, tree roots and soils were sampled and investigated either from dry or moist plots of a water-limited Scots pine forest in an inner-Alpine dry valley in Switzerland. The moist plots were experimentally irrigated for more than a decade in order to mitigate the water-stress.

Fine roots reacted to irrigation with an increase of biomass and production, and with a slight increase of the turnover rate. Concerning morphological traits of fine roots, only minor changes were observed for the root length and the amount of roots tips. Soils changed by altering their C contents within the various soil horizons, and the organic F-layer changed from a thick F-layer to almost no F-layer at irrigated sites, indicating a strong increase of the organic matter turnover.

water availability, forest soils, tree root traits

KG I - 1015 (Uni Freiburg)

IUFRO17-2249 **Root and shoot phenology of boreal trees in relation to waterlogging and soil freezing**

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(1) Natural Resources Institute Finland (Luke), Joensuu, Finland; (2) University of Eastern Finland, School of Forest Sciences, Joensuu, Finland

Abstract: Seasonal climatic events are key determinants of carbon allocation in trees. It is known that a large proportion of carbon fluxes within trees are directed belowground. However, most phenological studies are projected on monitoring and mathematical modelling of aboveground organs, with less attention on the phenology of roots. There is an obvious gap in the knowledge of root phenology and more studies concerning root phenology under the pressures of changing environmental factors are needed. Conditions that are predicted to change in the boreal zone in the future include soil moisture and temperature, presumably leading to increased waterlogging and soil frost.

We conducted laboratory experiments for studying the effects of soil waterlogging and freezing on fine root phenology of Scots pine (Pinus sylvestris) and silver birch (Betula pendula), and how the root phenology is coupled to the phenology of aboveground organs. We found clear changes in fine root phenology by waterlogging and soil freezing, like a change of biphasic growth pattern of short roots of Scots pine to one-peaked growth pattern after exposure to freezing of waterlogged soil during dormancy. Accordingly, we conclude that the changes in soil conditions in the boreal zone would have implications on root phenology and carbon allocation of tree seedlings.

Phenology, root, shoot, soil frost, waterlogging

KG I - 1015 (Uni Freiburg)

IUFRO17-579 **Active Recovery by Tree Roots**

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Abstract: The compaction of forest soils, caused by the accumulation of forest machinery traffic impact over decades on unprotected soils, has as a principal consequence the destruction of soil structure and thus, depth propagation of roots is limited to horizons where water and nutrient supply as well as gas exchange are simultaneously maintained.
The soil aeration status is a sensitive parameter for the assessment of soil damage; therefore, in order to detect the first effects of the recovery of soil structure in a compacted forest soil, treated with a combination of regeneration techniques, the relative apparent gas diffusion coefficient (Ds/D0) was analyzed for a replication of soil cores taken in 2012, 2014 and 2016. Also, the fine root density was assessed in 2016 in the investigation area.
Higher values of Ds/D0 were detected for samples taken in 2016 due to an initial recovery, resulting in an over-proportionate increase of Ds/D0 caused by the effects of the combination of the regeneration techniques, as well as the biological recovery processes, resulting in an increase of pore-connectivity.
The relationship between the relative apparent gas diffusion coefficient and the fine root density was also tested. Evidence that root density increases with increasing soil gas permeability was found.

compaction; gas diffusion coefficient; fine roots

Theme 5: Forests, Soil and Water Interactions

123 - Roots and Ecosystem Services

KG I - 1015 (Uni Freiburg)

IUFRO17-3761 **Analysing roots' response to low soil P supply**

Löw, C.* (1); Schack-Kirchner, H. (1); Krüger, J. (1); Lang, F. (1)

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Abstract: Global tree productivity is assumed to be limited by phosphorus supply. However, the mechanism of root-phosphorus supply in forest soils is poorly understood. Mycorrhiza and its extramatrical hyphae increasing the absorbing surface play an important role in phosphorus uptake. Until now no standard methods to quantify the extramatrical hyphae in natural soils are available. Our approach is to quantify the root surface as well as the extramatrical hyphae by a multi-level procedure. First the fine-root length per volume and root tip frequency per fine-root length is measured. From these soil samples a representative number of root tips are cut out with their soil environment and resin impregnated. On polished sections of these samples the number, the intensity of mycorrhization and the frequency of extramatrical hyphae are assessed by epifluorescence.
We will apply this method to characterize the rooting density along a geological P gradient to test whether rooting intensity, the spatial root distribution and the depth distribution of roots and hyphae is controlled by the P supply of soils. Results will be combined with data on the mobility of P in soils.

Phosphorus, Mycorrhiza, Extramatrical hyphae

KG I - 1015 (Uni Freiburg)

IUFRO17-1286 **Age of fine roots across a range of forest ecosystems**

Solly, E.* (1); Brunner, I. (1); Herzog, C. (1); Schweingruber, F. (1); Schöning, I. (2); Trumbore, S. (2); Schrumpf, M. (2); Hagedorn, F. (1)

(1) Swiss Federal Institute WSL , Birmensdorf, Switzerland; (2) Max Planck Instutite for Biogeochemistry, Jena, Germany

Abstract: Estimating the turnover rate of tree fine roots is one of the biggest challenges in soil ecology and one of the least understood aspects of the belowground carbon cycle. The methods used - ranging from radiocarbon to ingrowth cores and root cameras (minirhizotrons) - yield very diverse pictures of fine root dynamics in forest ecosystems with turnover rates reaching from less than one year to decades. These have huge implications on estimates of carbon allocation to root growth and maintenance and on the persistence of root carbon in soils before it is decomposed or leached.

For a range of forests with diverse water and nutrient regimes located at different latitudes, we used radiocarbon measurements to estimate mean "carbon ages" of fine roots, which define the time elapsed since carbon was fixed from the atmosphere. In parallel, we adopted a new approach, using plant anatomy techniques, to unravel the "real age" of fine roots.

We investigated annual growth rings in the secondary xylem of thin transverse sections of living fine roots belonging to tree species which form distinct growth rings. This analysis yielded root physiological ages of 1-2 years for temperate forests and indicated that in colder regions tree fine roots can live for several more years. Comparatively, radiocarbon estimates of mean carbon ages were on average a decade older (mixture of newly produced and older living roots). Newly produced roots in temperate forests however contained carbon fixed up to 1-2 years previously. This dramatic difference may not be related to methodological bias, but to a time lag between carbon assimilation and production of fine root tissues due to the storage of older carbon components in trees. Our findings suggest that both the physiological and mean carbon ages must be carefully accounted for to correctly quantify the inputs of root litter into the soil organic matter pool and the carbon persistence times in forests.

Fine roots, carbon, radiocarbon, anatomy

KG I - 1015 (Uni Freiburg)

IUFRO17-1990 **A diversity of fungi adapt to form relationships with adventitious rooting systems developing in canopy soils of an old-growth temperate rainforest**

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Abstract: Temperate rainforests of Washington are known for their unique old-growth forested ecosystems, due to high rainfall. Their vulnerability to climate change and what ecosystem components provide resilience to disturbances are not known. These forests form epiphytic organic mats on tree branches known as 'canopy soils', reaching depths >40cm. The paucity of research focusing on canopy soils, and their extensive adventitious rooting networks, correlates with the difficulty of accessing canopy branches. This research explores the diversity of root associated microflora and their impact on nutrient acquisition and allocation in canopy soils compared to the forest floor soils. The first objective was to determine whether the diversity of mutualistic fungal partners found in the canopy soils differ from the forest floor. A second objective was to measure how nutrient budgets differ between both environments and whether the diversity of mutualistic partners are correlated to nutrient fluxes. Initial DNA and morphological analyses provide evidence that adventitious roots and their mutualists are adapted to the unique canopy soil niche. Also, several unknown fungal associates were found in the canopy soils whose mycorrhizal affinities are being further explored. This research should provide insights on the resistance and resilience of these unique ecosystems facing climate change.

Canopy soil, roots, mycorrhiza, mutualistic

Theme 5: Forests, Soil and Water Interactions

41 - Forest rhizosphere ecology and biogeochemistry across environmental gradients

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1740 **Priming effect in boreal forest soils along a fertility gradient**

Karhu, K.* (1); Saarsalmi, A. (2); Kukkola, M. (2); Fritze, H. (2); Nykänen, H. (3); Ambus, P. (4); Pumpanen, J. (3); Ilvesniemi, H. (2)

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Abstract: Climate warming increases labile carbon (C) inputs to soil through increased photosynthesis and C allocation belowground. This could counterintuitively lead to losses of soil C via priming effects (PE): the stimulation of soil organic matter (SOM) decomposition caused by labile C addition. There is a need for a systematic quantification of PEs in relation to soil properties, before PEs can be explicitly represented in soil C models.

We measured PE along a site fertility gradient, from five sites belonging to Natural Resources Institute Finland's long-term fertilisation experiments. The gradient in C:N ratio of organic layers (reflecting site fertility) ranged from 24.1 to 46.2. Two of the sites were in Norway spruce (Picea abies (L.) Karst) stands, and three were in Scots pine (Pinus sylvestris L.) stands. We sampled soil from B1-layer (10-20 cm depth) of the control plot and an N-fertilised plot that had received N-amendments since the 1950's. We added 13C labelled glucose (2.04 atom %) to sieved soil at a rate of 15 mg glucose C per g soil C. Soils were incubated at 14 °C for 11 days in the laboratory, during which CO2 concentrations inside the bottles were measured every other day. The delta 13C of the respired CO2 was measured at the end of the experiment, to calculate PE.

The CO2-C released by PE was inversely related to soil total N % and mineral N concentrations, supporting the "microbial N mining hypothesis". However, the long-term N-fertilisation and N-additions in the lab, that we additionally studied, had inconsistent effects on the magnitude of PE, sometimes increasing and sometimes decreasing the magnitude of PE compared to control. Ongoing analysis of a 15N labelling experiment to determine gross N mineralisation and immobilisation rates using 15N pool dilution, will hopefully shed light on the reasons behind these variable responses. We also measured phospholipid fatty acids (PLFA) to see if PE was related to microbial community composition.

priming effect, boreal forest, microbial community

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3664 **14CO2 in combination with root-exclusion can be used to estimate plant-induced decomposition of soil organic matter**

Heinonsalo, J.* (1); Kulmala, L. (1); Mäkelä, A. (1); Oinonen, M. (1); Fontaine, S. (2); Palonen, V. (1); Pumpanen, J. (3)

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Abstract: In ecosystem models, the decomposition of soil organic matter (SOM) is estimated using temperature and moisture as main controlling parameters. However, there is increasing evidence that the decomposition is significantly affected by easily available carbohydrates. The C assimilation by the boreal forest trees will increase in the future due to climate change. As trees allocate large part of assimilated C to roots and soil microorganisms, particularly to ectomycorrhizal fungi, the rhizosphere priming effect (RPE) is assumed to increase. The aim of the experiment was to identify and quantify RPE in the field conditions. We established a three-year long trenching experiment in a boreal Scots pine forest where the belowground C flow from standing pine forest was controlled using root-exclusion with mesh fabrics. The mesh size of 1 um excluded both tree roots and fungal hyphae and served as priming controls with decreased C supply. The unaltered C input entered the non-trenched field plots. Soil CO2 flux and 14C concentrations were measured. We were able to quantify the RPE in field conditions and show that plant-derived C flow into the soil increases SOM decomposition. Quantification of RPE allows more detailed estimation of soil organic matter decomposition in future changing climate.

boreal, rhizosphere priming, soil organic matter

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3721 **The influence of roots on the decomposition of soil organic matter fractions in boreal forest soil**

Pumpanen, J.* (1); Lindén, A. (2); Bruckman, V. (3); Berninger, F. (2); Ilvesniemi, H. (4); Oinonen, M. (5); Sonninen, E. (5); Kukumägi, M. (6); Heinonsalo, J. (7)

(1) University of Eastern Finland, Kuopio, Finland; (2) University of Helsinki Dpt of Forest Sciences, Helsinki, Finland; (3) Austrian Academy of Sciences, Vienna, Austria; (4) Natural Resources Institute Finland (Luke), Helsinki, Finland; (5) Finnish Museum of Natural History - LUOMUS , Helsinki, Germany; (6) University of Tartu, Tartu, Estonia; (7) University of Helsinki Dpt of Food & Env. Sci, Helsinki, Finland

Abstract: Easily available carbon (C) has been shown to increase the mineralization of recalcitrant soil organic matter (SOM), but the combined effects of easily available carbon and living root system have rarely been studied. Our aim was to study the decomposition of easily soluble and recalcitrant SOM fractions and their 13C, 14C and 15N composition with and without the presence of living root system and glucose.

SOM collected from boreal forest soil organic horizon and incubated for 6 months with and without the presence of P. sylvestris seedlings and glucose was separated to three chemical fractions using pressurized hot water extraction (PHWE). The natural 13C, 14C and 15N abundances, spectral properties (FTIR-spectra) as well as the C and N pools of the SOM fractions were studied.

The living root system induced changes in natural abundancies of 13C, 14C and 15N and FTIR spectra in SOM fractions compared to root-free soil. Our results also indicated that the supposedly solid and more recalcitrant SOM fraction may not necessarily consist of older matter than the soluble fractions and that neither the 14C, 13C or 15N abundancies or spectroscopic methods alone cannot be used for describing the recalcitrance of SOM and its accessibility to micro organisms.

13C, 14C , 15N, FTIR, rhizosphere, priming

Theme 5: Forests, Soil and Water Interactions

41 - Forest rhizosphere ecology and biogeochemistry across environmental gradients

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-812 **Long-Term Simulated Atmospheric Nitrogen Deposition Alters Leaf and Fine Root Decomposition**

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Abstract: Investigations across boreal and temperate forests in Western Europe and North America have shown that atmospheric nitrogen (N) deposition is a major driver of forest carbon (C) accumulation. Plant litter decomposition drives major flows of C in soil systems and N deposition can alter C transformations and storage in soil. We studied the experimental effects of more than 22 years of N deposition on leaf litter and fine root decomposition along a 500-km climate and ambient N deposition gradient in the USA. Compared with leaf litter, fine roots contained 2.9-fold higher acid-insoluble fraction (AIF) and 2.3-fold more condensed tannins (CTs); both are relatively difficult to decompose. At an ecosystem scale, fine roots contributed over two-thirds of the fluxes of AIF and CTs to soil. Nitrogen additions marginally stimulated early-stage decomposition of leaf litter, but inhibited the later stages of fine root decomposition. At the ecosystem scale, slower fine root decomposition led to additional root mass retention (g m-2), and this greater retention of root residues was estimated to explain 5 to 51 % of previously-documented carbon accumulation in the surface soil due to N additions. Further chemical analysis revealed that the selective preservation of lignin is a major mechanism for the inhibition of fine root decomposition. Although N deposition studies have focused on leaf litter, these results highlight the important role of fine roots in plant-soil C fluxes and soil C storage and suggest that slower fine root decomposition is a major driver of soil organic C accumulation under elevated N deposition.

soil carbon root biogeochemical cycling

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-2966 **The ability of beech seedlings to shape their rhizosphere in order to cope with low P availability**

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Abstract: The objective of this study was to assess to what extent trees contribute actively to the mobilization of phosphorus in its rhizosphere and thus its own P nutrition. Under the assumption that plant induced P mobilizing activity depends on both the plant internal P nutrition status and its genetic memory of how to react under a given nutritional situation, the stated research question was tested by growing different beech phenotypes in soil from their own provenance and in soil differing in P availability. In the first year of the experiment, based on various indicators, and irrespective of the soils they were growing in, the total and metabolic P content in the leaves of juvenile trees (10 to 15 years old) clearly reflected the P availability of the provenance soil. Concurrently analysing the spatial heterogeneity of parameters relating to the mobilisation of P in the rhizosphere indicated that while plants appear to actively influence the occurrence of substances involved in mobilizing mineral bound P, they may have to rely on the microbial community to access organic P. Differences in the function and taxonomy of rhizosphere microbial communities among beech soil combinations will be interpreted with respect to targeted root-soil interactions.

phosphorus, rhizosphere, beech

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-1807 **Influence of the ectomycorrhizal colonizationtype on root functions under drought stress**

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Abstract: The mycorrhizal association is known to influence plant growth, nutrient cycling and soil C storage, but systematic differences in important root functions between major types of mycorrhizae, i.e. arbuscular (AM) and ectomycorrhizae (ECM), remain poorly understood. Such classification according to mycorrhizal colonization types may offer the chance, though, to develop a frame concept for the prediction of ecosystem responses to global change. Our study investigates the influence of the mycorrhizal association and drought stress on important root functions like root exudation (in situ collection) and N uptake capacities (15N-feeding experiments), and is complemented by aboveground investigations of photosynthesis and leaf respiration. We investigate the influence of indigenous mycorrhizae for root functions in young trees under controlled drought stress in the Göttingen Rhizolab. We hypothesized that (H1) root exudation is higher in ECM than in AM trees, (H2) exudation is altered by drought stress particularly in ECM trees, and (H3) the limited saprotrophic capacity of AM fungi increases the importance of organic N uptake for AM trees. We found no significant difference in root exudation between AM and ECM saplings at ample soil moisture; while exudation increased significantly in ECM saplings under drought stress to rates 1.5 times higher than in AM saplings. In addition, the proportion of photosynthates released by exudation increased significantly in ECM saplings in dry soil. Organic N uptake rates were not influenced by the mycorrhizal associations, which is in contrast to our hypotheses (H3). We conclude that ECM fungi actively increase the amount of root C exudation to dry soil which possibly increases the bioavailability of SOM, while the higher mineral N content in AM-dominated ecosystems makes such strategy unviable.

drought, exudation, mycorrhiza, N uptake, priming

Theme 5: Forests, Soil and Water Interactions

41 - Forest rhizosphere ecology and biogeochemistry across environmental gradients

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3133 **Responses of fine root dynamics and mycelia production to climate-change driven treeline advances**

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Abstract: There are a number of environmental factors and ecological processes that change abruptly within just a few altitudinal metres at the treeline: snow cover, albedo, soil temperatures, vegetation, microbial communities and carbon and nutrient dynamics. Climate change-driven forest expansions into the tundra will consequently have a tremendous impact on ecosystems and their functions.

In the pristine South and Polar Ural mountains with shifts of the treeline ecotone documented by historical photographs, we investigated fine root dynamics and production of extramatrical mycorrhizal mycelia (EMM) along four elevational transects reaching from the closed forest to the treeless tundra. In addition, we analyzed elevational differences in climate and vegetation structure, and excavated trees to estimate related changes in the partitioning between below and aboveground biomass.

Fine root biomass of trees (<2mm) increased by 13-79% with elevation, paralleled by a 35-72% increase in ground vegetation fine roots from the closed forest to the tundra. During the first year of decomposition, mass loss of fine root litter from different vegetation types was greater at lower elevations in the forest-tundra ecotone. The ratio between fine roots of trees and stem biomass largely increased with elevation in both regions, but these increases were not accompanied by a distinct production of EMM. Production of EMM however increased with the presence of ectomycorrhizal trees at the transition from the tundra to the forest.

Our results imply that the recorded upward expansion of forest into former tundra in the Ural mountains by 4-8 m per decade, is decreasing the partitioning of plant biomass to fine roots. This decrease is primarily associated to changes in the tree and ground vegetation cover and probably to increases in N availability. Moreover, climate-driven forest advances will alter EMM production rates with potential feedbacks on soil carbon and nutrient cycling in these ecosystems.

Fine roots, Mycelia, Global change, Treeline

Room "Baden-Baden" (Novotel Freiburg)

IUFRO17-3957 **The impacts of forest management practices of Norway spruce on soil fungal communities in the Alps**

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Abstract: A metagenomic study, using a 454 pyrosequencing platform, was undertaken targeting fungal ribosomal ITS amplicons from the A horizon of six Norway spruce (Picea abies) forest soils in the north-eastern Italian Alps, region with extraordinarily rich biodiversity. Stands were chosen close to the treeline having differing bedrock material including acid, basic and intermediate types, facing northern or southern slope aspect and being in one of four stand age classes such as gap, innovation, aggradation and biostatic for a total of 24 plots. The aim of the project was to assess the fungal diversity dynamics across a range of different conditions and to verify the shaping effects exerted by the above environmental factor functions. We also attempted to gain greater insight into the diversity of forest soil fungal communities exposed to various degrees of forest soil chemical conditions as well as the physical and vegetational divergences. Correlations among fungal classes were also investigated. Annotation of the OTUs yielded by the ITS sequencing generated a total of 338 fungal genera, ranging between 43 and 115 across plots. A number of strong positive or negative correlations were detected between different classes and between these and soil parameters including distinct soil organic matter compounds and forest cover patterns. This study demonstrated that deep sequencing can elucidate fungal community diversity in different environments and forest structures and that this information can have important implications for forest management in different forest sites and structures to preserving and enhancing forest resilience.

soil fungi, metagenomics, NGS, mycobiota

Theme 5: Forests, Soil and Water Interactions

60 - Open Session

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1261 **Stand property and litter mixture effects on the decomposition rates of total litter and different carbon chemical compositions in the monospecific and mixed subtropical plantations**

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Abstract: Litter decomposition responds to forest management in complex ways, and the outcome may significantly depend on biodiversity. A field litterbag experiment was conducted in the monospecific and mixed plantations of *Pinus massoniana* (PM) and *Castanopsis hystrix* (CH) in subtropical China to examine the stand property and litter mixture effects on the decomposition rates of total litter and different carbon (C) chemical compositions during a year period. Five litter decomposition types were examined: (1) PM litter in the PM plantation, (2) PM litter in the mixed plantation, (3) CH litter in the CH plantation, (4) CH litter in the mixed plantation, and (5) mixture of PM litter and CH litter in the mixed plantation. PM litter exhibited a faster decomposition rate in the mixed plantation than in the PM plantation. The decomposition rates for aromatic and carbonyl C of PM litter were also faster in the mixed plantation than in the PM plantation. Litter mixture hastened litter decomposition rate of PM, whereas slowed the decomposition rates of total litter and aromatic and carbonyl C of CH in the mixed-species bags. The higher soil nutrients in the mixed plantation than in the PM plantation could result in the positive effects on the decomposition rates of total litter and C chemical compositions of PM in the mixed plantation. The lower quality of PM litter could cause the negative effects on the decomposition rates of total litter and C chemical compositions of CH in the mixed-species bags. The results highlight that mixed plantation strongly impacts soil property and litter quality, and hence total litter and C chemical compositions decay rates. Diverse plant communities should be maintained to accelerate the recalcitrant litter turnover and mitigate C emission derived from the labile litter.

litter decomposition; litter mixture; mixed forest

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1685 **Drought response of individual tree species in mixed conifer stands**

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Abstract: Norway spruce (Picea abies), a widely cultivated species in Central Europe is susceptible to intense droughts, which are projected to increase in the future, and is therefore predicted to decrease substantially over this century. On the one hand, drought sensitivity of spruce may be lower in mixed species stands. On the other hand, the risk to lose large forest areas may be lower in mixtures. Therefore, we assessed the performance of spruce and the presumably more drought-resistant Silver fir (Abies alba) and Douglas fir (Pseudotsuga menziesii) in mixed-conifer stands.
Through dendro-ecological analyses, we assessed the resistance, resilience, and recovery of annual tree ring growth in the three species to the drought event of 2003. Tree cores were collected from 270 trees per species in 18 managed stands situated along three altitudinal gradients (400-1200 m a.s.l.) at the western slopes of the Black Forest in south-west Germany. We investigated tree neighbourhoods of different composition to quantify the complementarity effects for each target tree.
Overall, Silver fir and Douglas fir were significantly more resistant and resilient to drought than spruce. The neighbourhood composition had an effect on the capability of the species to resist and recover from the drought, besides influencing their performance in "normal years" (2007-2014). Generally, the performance of Norway spruce was improved in mixed neighbourhoods and its recovery and resilience to drought was mostly increased by species diversity. Silver fir clearly benefitted from mixed-species neighbours in normal growing conditions and through enhanced resistance and resilience in relation to drought. In contrast, increasing species mixture had a consistent antagonistic effect on Douglas fir radial growth. Our study shows that both Douglas fir and Silver fir may be suitable alternatives to Norway spruce, yet the latter appears to be more suitable for mixtures than the former.

Dendroecology, Drought-stress, Forest Management

K 5-7 (Konzerthaus Freiburg)

IUFRO17-2489 **CHiMP - Efforts to Conserve Highland Flora in Peninsular Malaysia**

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Abstract: Cameron Highlands, Peninsular Malaysia, nestled at elevations ranging from 1100 - 1600 m above sea level, thus reside several montane or cloud forests. However, the environment needs urgent attention and should be safeguarded. These montane ecosystems are currently threatened by illegal logging, land conversion for plantation, illegal collection and even the climate change. Followed by their natural habitat loss, soon the montane flora will be diminished. Cameron Highlands Montane Park (CHiMP) was established through joint efforts between Forest Research Institute Malaysia (FRIM); Forest Department of Peninsular Malaysia and Forest Department Pahang. Located at Tanah Rata in Cameron Highland, CHiMP is a dedicated area for highland botanical garden. Through years of ex-situ collection efforts, around 500 native species representing 15% of total montane species in Peninsular Malaysia were displayed in this 10 ha area. This was segmented into 13 showcase gardens which are ginger, aroid, begonia, rhododendron, highland ornamentals, wild, terrestrial and epiphythic orchids, montane herbs, bamboo, fern, palm and pitcher plant. This project is dedicated to conserve montane flora and save the highland ecosystem from imminent threats. To date CHiMP houses various types of native and endemic montane flora collected from 8 states and 17 forest reserve areas.

As the plants begin to establish and grow, several studies were conducted especially in determining the survival rate of ex-situ plants. Besides that initial activities of phenological observation upon the garden collections was conducted to regulate the plants reproductive cycle. Such long-term studies are required to understand plant adaptability which later assist in the strategies for montane species ex-situ collections process.

Montane native flora, conservation, botanic garden

Theme 5: Forests, Soil and Water Interactions

55 - Highland Rainforests Threats and Strategies for Sustainable Ecosystem Management

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1882 **Floristic composition and stand structure in a watershed rainforest in Nigeria: Implications for biodiversity conservation**

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Abstract: The watershed forest surrounding Arinta waterfall, Ipole Iloro, Nigeria is a pristine habitat faced with anthropogenic threats associated with increasing patronage from local and foreign tourism. Unfortunately, the floristic composition, plant distribution and stand structure of the watershed forest surrounding the waterfall have not been documented. We determined the plant diversity, distribution and stand structure along the gradient of the waterfall. Using a stratified sampling technique, five 0.04ha plots were laid on each of three strata (lower: 456m, middle: 470m and upper: 489m above sea level). All plant forms were identified and enumerated, while the diameter at breast height (dbh) and total height of trees were measured. The data were used to determine community diversity indices for the watershed rainforest. Ninety-six plant species (1 grass, 3 ferns, 15 herbs, 14 climbers, 14 shrubs and 49 trees) from 36 families were identified, while mean dbh ranged from 14.93cm - 43.83cm and mean height ranged from 9.27m - 18.16m. The Shannon Weiner and Simpson's indices ranged from 2.7 - 3.0, and 0.92- 0.95, respectively for trees. Also the species richness ranged from 20-24, while eveness ranged from 0.66-0.75. Four plant species threatened by habitat loss (Brachystegia kennedyi, Khaya ivorensis Pycnanthus angolensis, Pterygota macrocarpa and Diospyros mespiliformis) were encountered. Piptadeniastrum africanum which is an indicator species had the highest important value index. There was an inverse relationship between the density of ground flora and increasing elevation. However, tree natural regeneration was high in the understorey. The protection of this highly diverse watershed rainforest is paramount to ensuring continued biodiversity conservation and watershed protection for the rural communities. Plant conservation in natural, relatively undisturbed environment is one way of ensuring environmental sustainability.

Waterfall, topography, habitat conservation

K 5-7 (Konzerthaus Freiburg)

IUFRO17-1906 **Harmonizing agriculture for food security and forestry for conservation at tropical montane rainforests**

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Abstract: Cooler temperature resembling the temperate spring climate, sufficient sun rays and high rainfall intensity are combination factors attracting modern farmers to occupy fragile montane areas for commercial farming of high values commodity crops. Adding to the said plus point, this sort of climatic phenomenon is all year round, making it highly profitable for intensive agriculture. We present here the case study in Peninsular Malaysia Highland popular for its wide variety of exotic and local agriculture produce consisting of vegetables, fruits and flowers, largely for export market. The soils from the mountain top down the hill and connecting lowland were of Ultisols Order developed from granite rocks. They were old soils reaching ultimate stage of weathering. At the mountain top, soils were overlying with highland peat, reducing in thickness down the elevation, subsequently having duff layer then organic soil layer with histic epipedon. Eluviation is common for these soil profiles due to high rainfall intensity leading to nutrient transport from upper horizon to the subsoil. Cooler temperature and high rainfall create anaerobic environment slowing decomposition of litterfall. Soil quality does not matter to the farmers adopting raised bed system or those using altered soil media in pots. Even then, the rich organic layer was removed as precautionary measures to eradicate pest and diseases, apart from ease of constructing beds and farming house. For traditional farming, organic layers were plough to prepare for planting beds with high input of fertilizers. These farming practices on montane sites can be highly detrimental to the soil and ecosystems without effective control measures and buffers. Should forest remains at these areas or should we restrict agriculture activities? Findings from short assessment revealed that many farmers do not adhere to the guidelines on steep land farming and soil degradation is a major concern which reforestation becomes necessary.

Highland farming, hill forest, isothermic, perudic