# Modelling the impact of atmospheric nitrogen deposition on french forests in the context of climate change

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# INTERNATIONAL CONFERENCE
## Tackling climate change: the contribution of forest scientific knowledge

# BOOK OF ABSTRACTS

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# CONFÉRENCE INTERNATIONALE
## Faire face au changement climatique : la contribution de la science forestière

**21 - 24 May, 2012**

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# IMPACTS

## May 21, 2012

## 16:15- 18:00. Scientific Parallel Sessions 1

## ‘Hot-spots’ of climate change impacts in European forests – results of a questionnaire

Prof. Dr., Peter, SPATHELF - Department of Forest and Environment, Eberswalde University for sustainable development - Germany

Ernst, VAN DER MAATEN - Institute for Forest Growth, University of Freiburg - Germany

This study presents results of a European-wide questionnaire, developed to identify ‘hot spots’ of climate change impacts on forests. We defined hot spots as spatial delimitations of very responsive forest sites, structures and tree species compositions. Replies to the questionnaire came from experts from 17 European countries. The questionnaire addressed different aspects such as 1) observed and expected changes in climate and associated impacts on forests, 2) sensitivities of individual tree species and provenances, 3) characterization of vulnerable forest sites, and 4) necessity or application of adaptive forest management. We discuss important impacts of climate change on forests at a European scale, as well as differences and similarities between regions. Results are relevant to set priorities for pro- and reactive forest management. This contribution is based on the work of COST Action FP0703 ECHOES Working Group 1 “Impacts” (http://www2.gip-ecofor.org/echoes).

## Zones sensibles aux impacts du changement climatique dans les forêts européennes – résultats d'un questionnaire

Cette étude présente les résultats d'un questionnaire réalisé à l'échelle européenne et destiné à identifier les zones forestières sensibles aux impacts du changement climatique. Ces zones sensibles correspondent aux délimitations dans l'espace des sites forestiers, des structures et des compositions d'essences d'arbres très réactifs. Les réponses sont fournies par des experts de 17 pays européens. Le questionnaire portait sur différents aspects : 1) changements climatiques observés et attendus et impacts associés sur les forêts, 2) sensibilité des essences et des provenances, 3) caractérisation des sites forestiers vulnérables, et 4) nécessité d'appliquer une gestion forestière adaptative. Nous abordons les principaux impacts du changement climatique sur les forêts à l'échelle européenne, ainsi que les différences et les similitudes entre les régions. Les résultats servent à définir les priorités d'une gestion forestière proactive et réactive. Cette contribution se fonde sur le travail du Groupe de travail n°1 « Impacts » de l'Action COST FP0703 ECHOES (http://www2.gip-ecofor.org/echoes).

# Impact of climate on trees: identification of proxies in trees for measuring climatic stress

Mr Armand, TENE - UCD, Forest Research UK - Ireland
Dr Brian TOBIN - UCD - Ireland
Dr Duncan RAY - Forest Research - United Kingdom
Dr Kevin BLACK - FER - Ireland | kevin.black@ucd.ie
Pr Maarten NIEUWENHUIS - UCD - Ireland

Climate change may alter physiological and phenological processes in trees, leading to altered species distribution, forest compositions, resilience, and productivities (Kramer et al., 2000; Haninen et al., 2001). A better understanding of tree growth-climate relationships may help in predicting the potential impacts of climate on forest ecosystems (Cook and Cole, 1991). Distribution of vegetation across the globe largely depends on direct disturbance by management and indirect disturbance through altered atmospheric chemistry and climate. Investigations on growth trends of European forests have indicated increasing forest growth and forest site productivity in central Europe and southern Scandinavia (Kauppi et al., 1992). However, studies carried out in northernmost Europe have not revealed such trend-like changes in forest productivity (Mielikainen and Timonen, 1996). This suggests that growth trends in Europe may not have followed a uniform pattern and emphasises the need for investigating climate-growth relationships of trees in different areas. Tree-ring studies can describe long-term relationships between radial growth and climate (Fritts, 1976). Several studies suggest that species often express unique radial growth responses to climate (Makinen et al., 2002; Pederson et al., 2004; Goldblum and Rigg, 2005); which may reflect species optimal growing conditions and distinct growth-climate mechanisms (May, 1974; Bazzaz, 1987; He et al., 2005). Spatial comparison of long time series of tree growth enables one to identify environmental driving forces of growth variation and underlying mechanisms behind it (Hakinen et al., 2002). Impacts of environmental factors on tree growth are known to change gradually across altitudinal and longitudinal gradients; Spatial and temporal gradients also offer possibilities for formulating more specific hypotheses on the effects of changing climate on tree growth over time, mirrored by tree responses during years of severe climatic stress (Drought). Such analyses are useful tools for assessing the responses of forest ecosystems to possible changes in future global climate. However, the nature of this relationship within and across species, as well as across a wide geographic and climatic range remains unclear. This study, based on a methodology published by Tene et al., (2011), analyses growth responses to climatic variables across a transect from East England to West Ireland, for three species (DF, SS and SP) in an attempt to identify climatic driving forces for radial growth and C-O isotope discrimination and, further understand and explain the mechanisms involve in the process.

## Impact du climat sur les arbres : identification des données indirectes des arbres pour l'évaluation des contraintes climatiques

Le changement climatique peut modifier les processus physiologiques et phénologiques des arbres, et entraîner une modification de la distribution des essences, de la composition des forêts, de leur vitalité et de leur productivité (Kramer et al., 2000 ; Haninen et al., 2001). Une meilleure compréhension des relations entre le climat et la croissance des arbres peut aider à prévoir les impacts potentiels du climat sur les écosystèmes forestiers (Cook et Cole, 1991). La distribution de la végétation sur la planète dépend largement des perturbations directes par gestion et des perturbations indirectes par modification du climat et de la composition chimique de l'atmosphère. Les études sur les tendances de croissance des forêts européennes indiquent une hausse de la croissance et de la productivité en Europe centrale et dans le sud de la Scandinavie (Kauppi et al., 1992). Dans le nord-ouest de l'Europe, les études menées ne révèlent toutefois pas de tendance similaire en matière de productivité (Mielikainen et Timonen, 1996). Ces éléments confirment que les tendances de croissance en Europe peuvent ne pas suivre de schéma uniforme ; ils soulignent en outre le besoin d'étudier les relations entre climat et croissance des arbres dans les différentes régions. L'analyse des cernes de croissance permet de décrire les relations à long terme entre croissance radiale et climat (Fritts, 1976). Plusieurs études suggèrent que les essences expriment souvent une réponse unique au climat en matière de croissance radiale (Makinen et al., 2002 ; Pederson et al., 2004 ; Goldblum et Rigg, 2005). Ces aspects peuvent éclairer les conditions optimales de croissance d'une essence et les mécanismes distincts croissance-climat (May, 1974 ; Bazzaz, 1987 ; He et al., 2005). La comparaison dans l'espace de séries longues de croissances d'arbres permet d'identifier les forces environnementales à l'œuvre derrière les variations de croissance et les mécanismes sous-jacents. (Hakinen et al., 2002). L'impact de ces facteurs sur la croissance des arbres évolue progressivement selon l'altitude et la longitude : ces gradients spatiaux et temporels permettent également de formuler des hypothèses plus spécifiques sur les effets sur la croissance des arbres de l'évolution du climat, tels que reflétés par la réponse des arbres aux contraintes climatiques sévères (sécheresse). De telles analyses servent d'outils pratiques pour évaluer la réponse des écosystèmes forestiers aux évolutions possibles du climat global. Néanmoins, la nature de cette relation au sein des essences et entre elles reste floue, de même que sur une échelle géographique et climatique élargie. Cette étude, fondée sur la méthodologie publiée par Tene et al. (2011), analyse la réponse de croissance aux variables climatiques sur un transect qui s'étend de l'est de l'Angleterre à l'ouest de l'Irlande, pour trois essences afin d'identifier les facteurs d'influence climatique sur la croissance radiale et la discrimination isotopique Co. L'objectif est également de mieux comprendre et expliquer les mécanismes impliqués dans le processus.

# Integrating parameter uncertainty of process-based forest models in assessments of global change impacts on forest productivity

Christopher, REYER - Potsdam Institute for Climate Impact Research – Germany
Michael, FLECHSIG - Potsdam Institute for Climate Impact Research – Germany
Petra, LASCH - Potsdam Institute for Climate Impact Research – Germany
Marcel, VAN OIJEN - Centre for Ecology and Hydrology (CEH-Edinburgh) - United Kingdom

Process-based forest models are important and widely used tools to assess the impacts of global change on forest ecosystems. They represent mechanistic descriptions of forest processes in varying levels of detail as well as spatial and temporal resolution and strive to capture essential system dynamics. In most cases these models contain many parameters that are derived from few and very specific ecophysiological measurements. This leads to a considerable parameter uncertainty especially if the model is applied to sites across the distribution range of a tree species in which phenotypic and genotypic variation prevail. Here we use Bayesian calibration and a Monte Carlo Markov Chain algorithm in a generic and model-independent setting of a simulation environment to assess the effects of parameter uncertainty on the predictions of the process-based forest model 4C on selected stands in Europe. These stands are part of a larger assessment of productivity changes under global change carried out in the framework of the MOTIVE project (See submission by Lasch et al. to session 3). We focus primarily on Scots Pine (Pinus sylvestris) stands in Finland, Germany and Belgium for which detailed growth data is available. More specifically, we calibrate 4C on specific sites to test whether a regional parameter set improves the model predictions of past conditions in comparison to a global parameter set. We quantify the prior and posterior uncertainty (before and after calibration) of the parameter variation for past conditions. Finally, we assess the influence of the calibration on the predictions of future forest productivity under scenarios of changing climate and atmospheric $CO_2$. This allows for a discussion of how to assess parameter uncertainty in parameter-rich, complex process-based forest models as well as the validity and suitability of such models for assessments of global change impacts on forest ecosystems across the distribution range of a tree species.

## Intégrer l’incertitude des paramètres des modèles forestiers fondés sur les processus dans l’évaluation de l’impact du changement climatique sur la productivité des forêts

Les modèles forestiers fondés sur les processus sont des outils importants et répandus pour évaluer l’impact du changement climatique sur les écosystèmes forestiers. Ils décrivent mécaniquement les processus forestiers à divers degrés de détail et de résolution spatiale et temporelle et s’efforcent de saisir les dynamiques systémiques essentielles. Dans la plupart des cas, ces modèles s’appuient sur de nombreux paramètres dérivés de quelques mesures écophysiologiques très spécifiques. Leur incertitude est considérable, particulièrement si le modèle s’applique à des essences d’arbres marquées par une forte variation des phénotypes et des génotypes. Nous utilisons ici la calibration bayésienne et un algorithme de type Monte Carlo par chaînes de Markov dans une configuration générique et indépendante du modèle de simulation pour évaluer les effets des incertitudes de paramètres sur les prévisions du modèle forestier fondé sur les processus 4C, sur des peuplements sélectionnés en Europe. Ces peuplements intègrent également une évaluation élargie des changements de productivité dans le contexte du changement climatique, menée dans le cadre du projet MOTIVE (Cf. contribution de Lasch et al. à la session 3). Nous nous concentrons principalement sur des peuplements de pins sylvestre (Pinus sylvestris) en Finlande, en Allemagne et en Belgique pour lesquels les données de croissance détaillées sont disponibles. Plus précisément, nous calibrons 4C sur les sites spécifiques pour tester si un lot de paramètres régionaux améliore les prévisions du modèle pour les conditions antérieures par rapport à un lot de paramètres globaux. Nous quantifions l’incertitude antérieure et postérieure (avant et après calibration) de la variation des paramètres pour les conditions antérieures. Enfin, nous évaluons l’influence de la calibration sur les prévisions de la future productivité forestière dans le cadre de scénarios d’évolution du climat et de la teneur en $CO_2$ de l’atmosphère. Ces données permettent de discuter des moyens d’évaluer les incertitudes des paramètres dans des modèles forestiers fondés sur les processus, complexes et riches en paramètres. Elles permettent également de débattre de la validité et de l’adéquation de ces modèles pour l’évaluation de l’impact du changement climatique sur les écosystèmes forestiers au sein de l’étendue de distribution d’une essence d’arbre.

# Using probabilistic climate change projections and an ecological site classification to assess the future risk of climate impacts on tree species in Britain

Michal, PETR - Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente – Netherlands
Dr. Ir. L.G.J.(Luc) BOERBOOM - Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente – Netherlands
Prof. Dr. Anne van der Veen - Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente – Netherlands
Duncan, RAY - Forest Research, Northern Research Station, Forestry Commission - United Kingdom

Forests are fragile ecosystems sensitive to external factors such as climate change. In the UK, the latest climate change projections (UKCP09) for all greenhouse gas emissions scenarios indicate warmer summers, milder winters and an increase in the number of extreme climate events (Murphy et al. 2009; Jones et al. 2009). The mean summer temperature projected for 2080s across the UK indicates a likely increase between 2.2 to 6.8°C (between 10% and 90% probability levels). In addition, the projections show a major increase in the frequency of extreme events – hot and dry summers (Jones et al. 2009). The consequences of such changes in mean and extreme climate conditions will have a major impact on forest ecosystems in the future. In Britain, historical climate records and biological observations provide strong evidence for climate change. The Central England Temperature monthly series has shown an increase of mean annual temperature by 1OC since the 1970s, and the first leafing of Quercus robur in Surrey, England, has advanced by 25 days over the last 50 years (Sparks and Gill, 2002). Extreme events such as summer heat and reduced summer rainfall in 2003, have shown negative impacts of extreme climate on forest productivity (Ciais et al. 2005). Knowing about the future climate impacts on trees is not enough for sustainable forest management. The adaptive capacity of trees to cope with these impacts, determined by their ecological amplitude, must also be considered. This study uses a vulnerability framework previously used in sustainable science (Turner et al. 2003) to address this compounded problem of species resilience, sensitivity and exposure. There is a limited knowledge of how probabilistic climate information supports the assessment of different risks to major tree species. In this project we utilize the UKCP09 probabilistic projections to indicate where and when trees are likely to become vulnerable to climate change impacts in order to enable forest managers and planners to adapt. This study adds a new perspective to the risk assessment with emphasis on the species selection, with the support of the Ecological Site Classification and spatial and temporal information available in the UKCP09 climate projections.

References: Ciais, P. et al., 2005.Europe-wide reduction in primary productivity caused by the heat and drought in 2003.Nature, 437(7058), pp.529-533. Available at: ://000232004800045. Jones, P.D. et al., 2009. UK Climate Projections science report: Projections of future daily climate for the UK from the Weather Generator. Murphy, J.M. et al., 2009. UK Climate Projections Science Report: Climate change projections. Sparks, T. and Gill, R., 2002. Climate change and the seasonality of woodland flora and fauna. In: M. Broadmeadow (Editor), Climate Change: impacts on UK forests. Forestry Commission, Edinburgh. Turner, B.L. et al., 2003. A framework for vulnerability analysis in sustainability science.Proceedings of the National Academy of Sciences of the United States of America, 100(14), pp.8074-8079. Available at: http://www.pnas.org/content/100/14/8074.abstract.

## Utilisation des stations probabilistes de changement climatique et d'une classification des sites écologiques pour évaluer le futur risque de l'impact climatique sur les essences d'arbres en Grande-Bretagne

Les forêts sont des écosystèmes fragiles, sensibles aux facteurs externes comme le changement climatique. Au Royaume-Uni, les dernières projections en matière de changement climatique (UKCP09) pour tous les scénarios d'émissions de gaz à effet de serre indiquent des étés plus chauds, des hivers plus doux et une augmentation du nombre d'événements climatiques extrêmes (Murphy et al. 2009 ; Jones et al. 2009). La température moyenne projetée pour les années 2080 au Royaume-Uni indique une augmentation probable comprise entre 2,2 et 6,8°C (niveau de probabilité oscillant entre 10 % et 90 %). En outre, les projections indiquent une forte augmentation de la fréquence des événements extrêmes – étés chauds et secs (Jones et al. 2009). Les conséquences de ces changements dans des conditions climatiques moyennes et extrêmes auront un impact majeur sur les écosystèmes forestiers. En Grande-Bretagne, les données climatiques et les observations biologiques attestent fortement du changement climatique. La série mensuelle de Central England Temperature indique une augmentation de la température moyenne annuelle de 1°C depuis les années 1970. Par ailleurs, le débourrement du chêne pédonculé dans le Surrey, en Angleterre, a avancé de 25 jours sur les 50 dernières années (Sparks and Gill, 2002). Des événements extrêmes, comme la canicule et la réduction des précipitations estivales en 2003, ont illustré l'impact négatif des climats extrêmes sur la productivité forestière (Ciais et al. 2005). Connaître le futur impact du climat sur les arbres ne suffit pas à une gestion forestière durable. La capacité adaptative des arbres à faire face à ces impacts, déterminée par leur amplitude écologique, doit également être prise en compte. Cette étude s'appuie sur un cadre de vulnérabilité utilisé auparavant dans les sciences durables (Turner et al. 2003) pour s'intéresser à la question complexe de la résistance des essences, de leur sensibilité et de leur exposition. La contribution fournie par les informations climatiques probabilistes dans l'évaluation des différents risques sur les principales essences d'arbres est une question qui souffre de connaissances limitées. Dans ce projet, nous nous appuyons sur les projections probabilistes UKCP09 pour déterminer où et quand les arbres sont susceptibles de devenir vulnérables aux impacts du changement climatique afin de permettre aux gestionnaires et aux planificateurs forestiers de s'adapter. Cette étude éclaire sous un jour nouveau l'évaluation des risques en insistant sur la sélection des essences, avec le soutien de la Ecological Site Classification et des information spatiales et temporelles disponibles dans les projections climatiques UKCP09.

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# Modelling the impact of atmospheric nitrogen deposition on french forests in the context of climate change

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The production and accumulation of reactive nitrogen (Nr) species in various environmental compartments have become a worldwide environmental concern over the last half century. The transfer of anthropogenic Nr between reservoirs in the environment and its atmospheric transport over long distances have significant consequences on natural and semi-natural ecosystems (acidification and eutrophication processes).Therefore, managing N emissions at the European and global scales is necessary to prevent such a transboundary environmental problem. Critical loads modelling approaches have been developed by the working grouping on effects (WGE) under the LRTAP convention (1979) in order to quantify the sensitivity of ecosystems to Nr and to assess the impact of N atmospheric deposition on species richness. Nowadays, it is evident that the transfer and impact of Nr on the ecosystems must be examined especially under the conditions of climate change. High temperatures and changes in water availability may affect Nr behaviour in terrestrial ecosystems, influencing its harmful effects. In this context, we investigate the combined effects of expected future changes in climate and N deposition on Nr behaviour, species richness and tree growth in french forest ecosystems. A coupled biogeochemical and ecological model ForSAFE-VEG was run on spruce dominated woodland using two N atmospheric deposition scenarios (Current European legislation 'CLE' and Maximum Feasible Reduction 'MFR') and three SRES climate scenarios (A2, A1B and B1). Our results show that for the period 2010-2100 under the A2 SRES scenario, the net N mineralization and NO3- leaching was significantly increased, indicating that the process of forest N saturation may occur rapidly under the conditions of high N atmospheric inputs and high temperature. Furthermore, the rise in temperature enhanced herbaceous plants cover (%) and decreased mosses cover (%), whereas the response of grasses appeared more heterogeneous. Under the A2 SRES scenario conditions, the grasses cover is higher under the CLE deposition scenario than under MFR scenario indicating the high affinity of this plant group to Nitrogen. Considering the CLE deposition scenario, the grasses cover remains lower under A2 SRES scenario than under B2 SRES scenario indicating the combined effects of temperature and N deposition on the grasses group. Critical load for Nr will still be exceeded by 2050 if Current Legislation (CLE) is maintained.

## Modélisation de l'impact du dépôt atmosphérique d'azote sur les forêts françaises dans le contexte du changement climatique

La production et l'accumulation d'espèces réactives de l'azote (ERN) dans des compartiments environnementaux variés sont devenues depuis une cinquantaine d'années une source de préoccupation environnementale mondiale. Le transfert de réservoirs d'azote anthropogène dans l'environnement et son transport atmosphérique sur de longues distances ont des conséquences significatives sur les écosystèmes naturels et semi-naturels (processus d'acidification et d'eutrophication). Pour prévenir ce problème, une gestion des émissions d'azote à l'échelle européenne et mondiale est nécessaire. Des méthodes de modélisation des charges critiques ont été développées par le Working group on effects (WGE) dans le cadre de la convention LRTAP (1979) afin d'évaluer la sensibilité des écosystèmes aux ERN et à l'impact du dépôt atmosphérique d'azote sur la richesse spécifique. Aujourd'hui, le transfert et l'impact des ERN sur les écosystèmes doivent de toute évidence faire l'objet d'un examen attentif, particulièrement au regard du changement climatique. Des températures élevées et une modification de la disponibilité des ressources en eau peuvent modifier le comportement des ERN sur les écosystèmes terrestres et influencer leurs effets nocifs. Dans ce contexte, nous étudions les effets combinés des futurs changements attendus en matière de climat et de dépôt d'azote sur le comportement des RNS, la diversité des essences et la croissance des arbres dans les écosystèmes forestiers français. Un modèle couplé biogéochimique et écologique ForSAFE-VEG a été appliqué sur les espaces boisés dominés par l'épicéa en utilisant deux scénarios de dépôt atmosphérique d'azote (Réglementation européenne actuelle « REA » et Réduction maximale envisageable « RME ») et trois scénarios climatiques SRES (A2, A1B et B1). Pour la période 2010-2100, dans le cadre du scénario SRES A2, la minéralisation nette d'azote et les infiltrations de nitrate augmentent de manière significative, le processus de saturation en azote des forêts peut donc survenir rapidement dans le cas de dépôts d'azote et de températures élevées. En outre, la hausse des températures renforce la couverture des plantes herbacées (%) et réduit celle des mousses (%), tandis que la réponse des graminées semble plus hétérogène. Sous le scénario SRES A2, la couverture par les graminées est plus élevée avec le scénario REA qu'avec le scénario RME, ce qui indique une forte affinité de ce groupe de plantes avec l'azote. Pour le scénario de dépôt REA, la couverture des graminées reste inférieure avec le scénario SRES A2 par rapport au scénario SRES B2, ce qui renseigne sur les effets combinés de la température et du dépôt d'azote sur le groupe des graminées. La charge critique pour les ERN restera toujours dépassée en 2050 si la Réglementation européenne actuelle est maintenue.

## New evidences of the impacts of global change at the southern edge populations of silver fir (Abies alba Mill.) distribution range

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Most global vegetation models predict migrations of species´ ranges as a response to climate change; however, detailed evidence of latitudinal or altitudinal shifts of woody species are still scarce. In this context, since the second part of past century, a decline of silver fir forests has been reported all around Europe, yet the causes of this decline remain poorly understood. Based on the 40 years of data from the Spanish National Forest Inventory, this work analyzes the spatio-temporal distribution of silver fir populations in the Spanish Western Pyrenees. Latitude, elevation and exposure were used as auxiliary variables in Universal Kriging to assess and to compare the distribution of different age classes of silver fir (mature forests and young forests) during the four decades this work covers. The results provide new evidence of vertical migrations and impacts in the growth and recruitment of forests. Variations in the climatic regime and changes in land use seem to be potential candidates driving the changes in the distribution and population structure of silver fir. These results present new clues to the understanding of global change impacts on mountain ecosystems.

## Nouvelles preuves de l'impact du changement climatique sur les populations situées à la lisière Sud de l'étendue de distribution du sapin blanc (Abies alba Mill.)

La plupart des modèles globaux en matière de végétation prévoient une migration des essences en réponse au changement climatique. Néanmoins, les preuves détaillées de migrations latitudinales ou altitudinales d'essences forestières restent rares. Depuis la seconde moitié du siècle dernier, un déclin des forêts de sapins pectinés a été observé partout en Europe, sans que les causes en soient toutefois pleinement comprises. Sur la base de 40 ans de données de l'Office espagnol des forêts, ce travail analyse la distribution spatio-temporelle des populations de sapins blancs dans les Pyrénées occidentales espagnoles. La latitude, l'altitude et l'exposition ont servi de variables auxiliaires en krigeage universel pour évaluer et comparer la répartition des différentes classes d'âges de sapins blancs (forêts jeunes et matures) au cours des quatre dernières décennies couvertes par cette étude. Les résultats apportent de nouvelles preuves des migrations verticales et des impacts sur la croissance et sur le recrû des forêts. Les variations de régime climatique et les changements d'affectation des terres semblent être des facteurs potentiels de modification de la répartition et de la structure de la population de sapins pectinés. Ces résultats présentent de nouveaux indices pour la compréhension de l'impact du changement climatique sur les écosystèmes de montagne.

# RESILIENCE 1

**May 21, 2012**

**16:15- 18:00. Scientific Parallel Sessions 1**

## Tree regeneration vulnerability to climate change: relative contributions of direct climate effects, plant interactions, herbivores & pathogens in mountain forests

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Climate change is expected to have strong impacts on mountain forests, with a complete reorganization of forest composition. There is however a high uncertainty about these impacts and we know little about the mechanisms underpinning climate change effects. For instance, climate change is likely to impact tree species recruitment, leading either to a lack of recruitment for a subset of species or to the recruitment of new species into the community. Understanding changes in species recruitment ability is crucial to develop sound management strategies. Tree recruitment is however complex because seed germination and juvenile seedling growth and survival are highly sensitive to both biotic and abiotic factors. In this study, we analyse how recruitment ability of dominant mountain tree species is affected by variation of climatic conditions. More specifically we untangle the direct effects of changes in climatic conditions and the indirect effects through changes in interactions with neighbourhood plants, or herbivores and pathogens. We used pots experiments, extensive long-term field experiment and monitoring of natural regeneration, exploiting the spatio-temporal variability of climatic conditions over numerous sites in the French Alps. We then inferred the relative contributions of direct climate effect, changes of interactions with plants, herbivores and pathogens using model based Bayesian inferences. Our results show that interactions with neighbourhood plants, herbivores and pathogens are crucial to predict the impact of climate change on tree recruitment ability.

# Vulnérabilité de la régénération des arbres au changement climatique : contributions relatives des effets climatiques directs, des interactions entre plantes, des herbivores et des pathogènes dans les forêts de montagne

Le changement climatique devrait avoir d'importantes conséquences sur les forêts de montagne et entraîner une complète réorganisation de leur composition. De fortes incertitudes planent toutefois sur ces impacts et nous en savons peu sur les mécanismes sous-jacents des effets du changement climatique. Par exemple, ce dernier est susceptible d'avoir un impact sur la régénération des essences d'arbres, entraînant soit un défaut de régénération pour un sous-ensemble d'essences ou une régénération de nouvelles essences dans la communauté. La compréhension des modifications de la capacité de recrutement des essences est essentielle au développement de stratégies de gestion judicieuses. Le recrutement reste toutefois complexe : la germination des graines et la croissance et la survie juvéniles sont très sensibles aux facteurs biotiques et abiotiques. Dans cette étude, nous analysons en quoi la capacité de recrutement des essences d'arbres de montagnes dominantes est affectée par la variation des conditions climatiques. Plus précisément, nous démêlons les effets directs des changements climatiques et leurs effets indirects sur les interactions avec les plantes voisines, ou les herbivores et les pathogènes. Nous nous appuyons sur des expérimentations, des expérimentations extensives et à long terme sur le terrain et un suivi de la régénération naturelle, en exploitant la variabilité spatiotemporelle des conditions climatiques sur de nombreux sites des Alpes françaises. Nous en déduisons les contributions relatives des effets directs du climat, des changements d'interactions avec les plantes, les herbivores et les pathogènes à l'aide de déductions bayésiennes fondées sur le modèle. Nos résultats indiquent que les interactions avec les plantes voisines, les herbivores et les pathogènes sont essentielles pour prévoir l'impact du changement climatique sur la capacité de régénération des arbres.

## Climate change and forest genetic resources: scientific challenges, risks and opportunities

Dr Judy LOO - Bioversity International – Italy
Dr Bruno FADY - INRA - France
Dr Ian DAWSON - ICRAF – Kenya
Dr Barbara VINCETI - Bioversity International - Italy Ms Giulia BALDINELLI - Bioversity International – Italy

This paper focuses on forest genetic resources (FGR). It was prepared at the request of the Commission on Genetic Resources for Food and Agriculture of the United Nations Food and Agriculture Organization (FAO). It seeks to review and examine the impacts of climate change on FGR that are important for human well-being, and the potential role of these resources in mitigating and adapting to change. In regions where climate change is expected to be extensive and rapid, many tree species are predicted to experience severe stress in their native ranges. Survival will then depend on the capacity to undertake at least one of the following: (1) quickly adapt genetically to new conditions at existing sites; (2) survive changing conditions through a high degree of phenotypic plasticity without genetic change; and/or (3) migrate rapidly to newly evolving environments that match basic physiological requirements. This paper considers forest genetic resources in the different settings where people depend on products and services from trees for a wide variety of purposes, including naturally regenerating forests, commercial plantations, and trees on farms (including planted trees and wild remnants left standing for various functions). The expected impacts of climate change – and hence strategies for responding to it – differ among these environments. Assisted migration and artificial selection for appropriate traits are approaches that can be applied to planted trees, whether in commercial plantations or farms, but are less appropriate for natural forests. However, management actions are confronted with serious challenges, including national and international policies that limit the movement of genetic resources among countries, and long regeneration cycles that make tree breeding time-consuming and costly. Adapting to climate change poses a greater problem for naturally regenerating populations where the potential for natural migration is hindered by forest fragmentation and agricultural expansion, and when confounding factors for adaption include pests and diseases, reduced population sizes, and simplified forest structures and species compositions. Lack of information on the following hinders our ability to manage climate change impacts better: (1) little is known about the sequences and functions of the genes conferring adaptation; (2) the genetic and epigenetic basis of phenotypic plasticity and its role in producing responses to environmental alterations is unclear; (3) the basic life-history characteristics, ecological determinants and geographic distributions of many trees are not well studied; and (4) meaningful syntheses of such information into predictive models of change and response are poorly developed.

## Changement climatique et ressources génétiques des forêts : défis scientifiques, risques et opportunités

Cette présentation se concentre sur les ressources génétiques des forêts. Elle a été préparée à la demande de la Commission des ressources génétiques de l'Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO). Elle cherche à analyser et à examiner l'impact du changement climatique sur les ressources génétiques des forêts importantes pour le bien-être des êtres humains. Elle s'intéresse en outre au rôle potentiel de ces ressources dans la réduction et l'adaptation au changement. Dans les régions où le changement climatique s'annonce radical et rapide, de nombreuses essences d'arbres devraient subir de fortes contraintes sur leur distribution d'origine. La survie dépendra alors de leur capacité à intégrer au moins l'un des aspects suivants : 1) adaptation génétique rapide aux nouvelles conditions sur les sites existants ; (2) survie à l'évolution des conditions par le biais d'un degré élevé de plasticité phénotypique sans changement génétique ; et/ou (3) rapide migration vers les environnements nouveaux répondant aux exigences physiologiques de base. Cette présentation porte sur les ressources génétiques des forêts dans les différents environnements où les populations dépendent des produits et des services fournis par les arbres pour de multiples objectifs, y compris les forêts à régénération naturelle, les plantations commerciales, et les arbres dans les fermes (y compris arbres plantés et spécimens sauvages laissés pour différentes fonctions). L'impact attendu du changement climatique – et par conséquent les stratégies pour y faire face – diffèrent selon les environnements. Une migration assistée et une sélection artificielle des caractéristiques appropriées sont des méthodes qui peuvent s'appliquer aux arbres plantés, qu'ils soient dans les plantations ou dans les fermes, mais qui sont moins adaptées aux forêts naturelles. Néanmoins, les actions en matière de gestion sont confrontées à de lourds défis, y compris les politiques nationales et internationales qui restreignent le mouvement des ressources génétiques, et les longs cycles de régénération qui rendent la génétique forestière chronophage et coûteuse. L'adaptation au changement climatique pose également un problème plus vaste pour les populations à régénération naturelle, où le potentiel de migration naturelle est entravé par la fragmentation des forêts et l'expansion agricole, et quand les facteurs de confusion incluent les nuisibles et les maladies, les tailles de populations réduites et les structures forestières et compositions d'essences simplifiées. Le manque d'informations dans les domaines suivants entrave notre capacité à mieux gérer l'impact du changement climatique : (1) les connaissances sur les séquences et les fonctions des gènes propices à l'adaptation sont minces ; (2) la base génétique et épigénétique de la plasticité phénotypique et son rôle dans la production de réponses aux modifications environnementales reste floue ; (3) les caractéristiques, traits de vie, les déterminants écologiques et la distribution géographique de nombreux arbres ne font pas l'objet d'études avancées ; et (4) les synthèses significatives de ces informations en modèles prédictifs de changement et de réponse sont une denrée rare.

## Adaptive silviculture regarding climate change: the geneticist's view

François LEFEVRE - INRA, URFM Avignon - France
Sylvie ODDOU-MURATORIO, Christian PICHOT, Bruno FADY, Etienne KLEIN, Hendrik DAVI, François COURBET, Philippe DREYFUS - INRA, URFM Avignon – France

Genetic diversity is a key parameter for the adaptation of forests to climate change. However, obtaining quantitative estimates of the contribution of genetic diversity to the resistance or the resilience of forests facing climate change is challenging. Focusing on the adaptive potential of forest trees through genetic evolution at local scale, we address the following questions: (1) how can we estimate the adaptive capacity of current tree populations? and (2) how can we improve this adaptive capacity through silviculture? To address these questions, we consider the genetic diversity in a dynamic rather than a static perspective. Indeed, genetic diversity is not solely the diversity of gene alleles: it is also the genotypic diversity of individuals, i.e. the diversity of allelic combinations. Individual genotypes, not just genes, are facing climate change. Thus, in the dynamic perspective, the evolution of genetic diversity in a forest proceeds from two mechanisms: inflations, i.e. emergence of new genotypic combinations, and erosions, i.e. elimination of genotypes through random drift and selection. We first review the literature which provides single-trait and multiple-trait estimates of the genetic parameters needed to infer the evolvability of tree populations. Then, using an approach to ecosystem dynamics that combines physiological, demographic and genetic processes (physio-demo-genetic modelling), we investigate how far silviculture can impact the evolution and the evolvability through its actions on local environment, demography, selection intensity and gene flow. Finally we consider some innovative and futuristic silvicultural practices and investigate how far they could contribute to preserve, and better improve, the evolvability of forest tree populations in the long term.

## Sylviculture adaptative dans le contexte du changement climatique : le point de vue du généticien

La diversité génétique est un paramètre clé de l'adaptation des forêts au changement climatique. Néanmoins, l'obtention d'évaluations quantitatives de la contribution de la diversité génétique à la résistance des forêts face au changement climatique est délicate. En nous concentrant sur le potentiel adaptatif des arbres par le biais d'une évolution génétique à l'échelle locale, nous soulevons les questions suivantes : (1) comment évaluer la capacité adaptative des populations d'arbres actuelles ? et (2) comment améliorer cette capacité par le biais de la sylviculture ? Pour y répondre, nous étudions la diversité génétique d'un point de vue dynamique plutôt que statique. De fait, la diversité génétique ne correspond pas uniquement à la diversité des allèles : elle est également la diversité génétique des individus, soit des combinaisons d'allèles. Ce sont les génotypes individuels, et pas uniquement les gènes, qui font face au changement climatique. Ainsi, d'un point de vue dynamique, l'évolution de la diversité génétique d'une forêt s'appuie sur deux mécanismes : les inflations, c'est-à-dire l'émergence de nouvelles combinaisons de génotypes, et les érosions, c'est-à-dire l'élimination de génotypes par l'intermédiaire de dérives et de sélections aléatoires. Nous analysons d'abord la documentation qui propose des évaluations simples et multiples des paramètres génétiques nécessaires pour déduire la capacité d'évolution des populations d'arbres. Puis, à l'aide d'une méthode des dynamiques d'écosystèmes qui associe les processus physiologiques, démographiques et génétiques (modélisation physio-démo-génétique), nous étudions la portée éventuelle de la sylviculture sur l'évolution et la capacité d'évolution par ses actions sur l'environnement local, la démographie, l'intensité de la sélection et les flux génétiques. Enfin, nous étudions quelques pratiques sylvicoles novatrices et futuristes et nous étudions à quel point elles peuvent contribuer à préserver, et même à améliorer, la capacité d'évolution des populations d'arbres forestiers sur le long terme.

## Modelling of photosynthesis in relation to light and environmental variables of natural regeneration of two mixed pinus pinea-quercus ilex-juniperus oxycedrus stands

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The changing climate situation, characterized by the transition to drier conditions in the Mediterranean basin, tends to hinder regeneration. This fact, joined to the high ecological, landscape and productive values of Spanish mixed stone pine-holm oak stands makes necessary to delve into the ecophysiological background of seedlings. We investigate the ecophysiological responses to micro-environmental conditions of three coexisting species (Pinus pinea, Quercus ilex and Juniperus oxycedrus) through modeling their photosynthetic capacity in relation to incident solar radiation, temperature and soil moisture. Two 0.45 ha plots were set up in two mixed stands differing in their structural typology. Forty-eight seedlings were chosen following a natural light gradient. Physiological measurements were done in ten dates, three measurements per date (predawn, morning and midday) between September 2010 and October 2011, including gas exchange parameters, chlorophyll a fluorescence, water status and micro-environmental variables (temperature and soil moisture). Gas exchange measurements represent a total of 113 inventories, covering a wide range of environmental conditions. We propose the parametrization of the non-rectangular hyperbolic model of photosynthesis proposed by Thornley & Johnson (1990) that relates gross photosynthesis rate with incident light for a particular moment. The advantage of fitting this model is that, although having an important biochemical basis, it is possible to use empirical data to modelize the relationship between gross photosynthetic rate and incident light through the estimation of three parameters: maximum rate of net photosynthesis (Amax), photochemical efficiency ($\alpha$) and convexity of curve ($\theta$). In a first step, we fitted the model for each inventory obtaining a combination of parameters. In a second step, climatic variables (soil moisture and temperature) were plotted against Amax and $\alpha$ in order to study their relationship. In a third step, a model was fitted to all the data by the expansion of the parameters Amax and $\alpha$. In all cases, non-linear regression models were fitted using least-squares method. This expanded model predicts photosynthetic capacity of natural regeneration under a suite of soil moisture and temperature scenarios for the three species. Our results indicate differences between the three species. Amax show a different response to temperature in Quercus ilex in comparison with the other two species. Under nonlimiting environmental conditions, Pinus pinea shows higher $CO_2$ assimilation than Juniperus oxycedrus in response to changes in temperature and soil moisture. In a high-temperature scenario, both Juniperus oxycedrus and Pinus pinea show very low $CO_2$ assimilation irrespective of soil moisture

## Modélisation, en fonction de la lumière et d'autres variables environnementales, de la photosynthèse de la régénération naturelle de deux peuplements mélangés de Pinus pinea, Quercus ilex et Juniperus oxycedrus.

Le changement de climat, caractérisé par une transition vers des conditions plus arides dans le Bassin méditerranéen, tend à freiner la régénération. Ce fait, cumulé avec les hautes valeurs écologiques, paysagères et productives des peuplements mélangés espagnols de pin pignon et de chêne vert, oblige à se pencher sur le contexte écophysiologique des plantules. Nous analysons, pour trois espèces en mélange (*Pinus pinea*, *Quercus ilex* et *Juniperus oxycedrus*), leurs réponses écophysiologiques aux conditions micro-environnementales à travers la modélisation de leur capacité de photosynthèse selon la lumière solaire incidente, la température et l'humidité du sol. Deux placettes de 0,45 ha ont été mises en place dans deux peuplements mélangés différant par leur structure. Quarante-huit plantules ont été choisies le long d'un gradient naturel de lumière. Des mesures physiologiques ont été réalisées à dix dates, à raison de trois mesures par date (avant l'aube, le matin et à midi) de septembre 2010 à Octobre 2011, avec prise en compte des paramètres d'échanges gazeux, de la fluorescence chlorophyllienne, de l'état hydrique et des variables micro-environnementales (température de l'air et humidité du sol). Les mesures d'échanges gazeux représentent un total de 113 inventaires, couvrant une large gamme de conditions environnementales. Nous proposons la paramétrisation du modèle hyperbolique non rectangulaire suggéré par Thornley & Johnson (1990), qui relie le taux de photosynthèse brute à la lumière incidente à un moment donné. L'avantage d'ajuster ce modèle est que, bien qu'ayant une importante base biochimique, il est possible d'utiliser des données expérimentales pour modéliser la relation entre le taux de photosynthèse brute et la lumière incidente à travers l'estimation de trois paramètres : le taux maximum de photosynthèse nette (Amax), l'efficacité photochimique ($\alpha$) et la convexité de la courbe ($\theta$). Dans une première étape, nous avons ajusté le modèle pour chaque inventaire et obtenu une combinaison de paramètres. Dans une deuxième étape, les variables climatiques (humidité du sol et température) ont été confrontées à *Amax* et $\alpha$ de manière à étudier leur relation. Dans une troisième étape, un modèle a été ajusté à toutes les données en étendant les paramètres *Amax* et $\alpha$. Dans tous les cas, ce sont des modèles non linéaires qui ont été ajustés par la méthode des moindres carrés. Le modèle étendu prédit la capacité photosynthétique de la régénération naturelle pour une série de scénarios relatifs à l'humidité du sol et à la température appliqués aux trois espèces. Nos résultats mettent en évidence des différences entre les trois espèces. *Amax* montre une réponse différente à la température pour le chêne vert en comparaison des deux autres espèces. Dans le cadre de conditions environnementales non limitantes, *Pinus pinea* montre une meilleure assimilation du $CO_2$ que *Juniperus oxycedrus* en réponse aux changements de température et d'humidité du sol. Dans un scénario de haute température, aussi bien *Juniperus oxycedrus* que *Pinus pinea* montrent une faible assimilation du $CO_2$ quelle que soit l'humidité du sol.

# Drought-adaptive potential of central and marginal provenances of European beech

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European beech, the major tree species of Central European deciduous forests, is reputed to be drought-sensitive. Thus, its future role in European forests remains rather unclear due to climate change. We performed various drought impact studies on beech using different provenances, central and marginal, growing under humid and xeric climate conditions. Higher soil water use efficiency under drought conditions was evident for the beech of marginal provenances compared to the central ones. Especially the prolonged water exploitation of the marginal provenances must be considered as an advantage of survival and competition under possibly more xeric conditions in the future. Studies are continued in an open field laboratory ('Drylab') under controlled precipitation conditions (mobile roofing system) using eight lysimeters equipped with soil moisture sensors and rhizotrone technique. We will discuss the adaptive potential of beech provenances to drought and future interactions between forest management, soil water availability and productivity in beech forests.

## Potentiel d’adaptation à la sécheresse des provenances centrales et marginales du hêtre européen

Le hêtre, principale essence des forêts caduques d’Europe centrale, est réputé sensible à la sécheresse. Son rôle futur dans les forêts européennes reste par conséquent relativement incertain au regard du changement climatique. Nous avons effectué diverses études d’impact de la sécheresse sur le hêtre en utilisant différentes provenances – centrales et marginales –, évoluant sous conditions climatiques humides ou arides. En période de sécheresse, une plus grande efficacité de l’utilisation de l’eau du sol est évidente pour le hêtre de provenance marginale par rapport aux spécimens de provenance centrale. Plus particulièrement, l’exploitation prolongée de l’eau des provenances marginales doit être considérée comme un avantage pour la survie et la compétition sous des conditions potentiellement plus arides à l’avenir. Les études se poursuivent dans un laboratoire sur le terrain (« Drylab ») sous des conditions de précipitations contrôlées (système de toit mobile) grâce à huit lysimètres équipés de capteurs d’humidité du sol et de techniques rhizotrones. Nous discuterons du potentiel adaptatif à la sécheresse de chaque provenance de hêtre et des futures interactions entre la gestion forestière, la disponibilité en eau du sol et la productivité des forêts de hêtre.

## What determines adaptability? A case study with silver birch

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Predicted climate change holds challenges for long-lived forest trees. Genotypic plasticity is a key factor for species survival, and capacity to acclimate and adapt is becoming more important in a changing climate. Differences in growth (or accumulation of biomass) between individuals within a species over a number of years provide a clue as to how well individual genotypes are adapted to current and future growing conditions or how well certain genotypes can tolerate adverse conditions. In our project we thus focus variability within a single population of Silver birch (Betula pendula Roth). For our study we exploit a birch experiment that was established in 1999 by randomly selecting 30 individuals for micropropagation from a naturally regenerated Silver birch stand in Punkaharju, Finland (61º48’ N, 29º18’ E). A thinning harvest –after 9 years- in a common garden experiment with these genotypes revealed a two-fold difference in biomass between the fastest and slowest growing genotypes. These large differences in above-ground biomass between genotypes give a strong signal of their adaptability and we propose that the fast-growing genotypes have superior capacity over the slow-growing ones to adapt to changing environmental conditions. These contrasting genotypes thus enable us to detect morphological, structural and functional mechanisms behind adaptability. During the 2010 and 2011 growing season we measured phenological, physiological (e.g. gas exchange, water potential) and morphological (e.g. SLA, stomata, trichomes) characteristics on short-shoot leaves of 15 genotypes, divided into 3 groups (fast, intermediate and slow growing) based on their biomass. Our results show that net photosynthesis (Pn) was not different between groups or individual genotypes in both years. In 2010 we found minor differences between groups for stomatal conductance, transpiration and WUE, but these were not present in 2011. Environmental and leaf-age effects were significant as indicated by the effects of year and sampling round. Hence, the accumulation of carbon through photosynthesis on its own does not explain the differences in biomass accumulation between genotypes or groups. Interestingly, we found that one genotype (genotype 18), used consistently more of the photosynthetic capacity (Pn ambient [CO2] / Pn saturating [CO2], in saturating light) throughout the growing season. Moreover, genotype 18, as well as the other fast-growing genotypes, produced relatively inexpensive, small leaves with high stomatal density. This indicates that these leaf traits may be important determinants in biomass accumulation, adaptability and acclimation to changing environmental conditions.

## Qu’est-ce qui détermine la capacité d’adaptation ? Une étude de cas sur le bouleau blanc

Le changement climatique annoncé renferme son lot de défis pour les arbres à grande longévité. La plasticité génotypique est un facteur clé de la survie des essences, et leur capacité à s’acclimater et à s’adapter gagne en importance dans un climat qui évolue. Les différences de croissance (ou d’accumulation de biomasse) entre les individus d’une même essence sur plusieurs années renseignent sur la capacité des génotypes individuels à s’adapter aux conditions de croissance actuelles et futures et à tolérer des conditions hostiles. Notre projet se concentre sur la variabilité au sein d’une population unique de bouleau blanc (Betula pendula Roth). Elle exploite une expérimentation établie en 1999 en sélectionnant de manière aléatoire 30 spécimens pour une micropropagation depuis un peuplement de bouleaux blancs régénérés naturellement à Punkaharju, Finlande (61º48’ N, 29º18’ E). Après neuf ans, une coupe d’éclaircie de ces génotypes dans un jardin expérimental a révélé une double différence de biomasse entre les génotypes à croissance plus rapide et ceux à croissance plus lente. Ces différences majeures de biomasse en surface entre les génotypes donnent un signal fort de leur capacité d’adaptation à l’évolution des conditions environnementales. Nous disons que les génotypes à croissance plus rapide ont une capacité supérieure à celle des génotypes à croissance lente à s’adapter à un changement des conditions environnementales. Ces génotypes contrastés nous permettent ainsi de détecter des mécanismes morphologiques, structurels et fonctionnels sous-jacents à cette capacité d’adaptation. Pendant la saison de croissance 2010 et 2011 nous avons mesuré les caractéristiques phénologiques, physiologiques (par ex. échanges gazeux, potentiel hydrique) et morphologiques (par ex. superficie foliaire spécifique, stomates, trichomes) sur les jeunes pousses de 15 génotypes, divisées en trois groupes (croissance rapide, intermédiaire et lente) sur la base de leur biomasse. Les résultats indiquent que, sur les deux années, la photosynthèse nette (Pn) ne diffère pas selon les groupes ou les génotypes individuels. En 2010, nous avons constaté des différences mineures entre les groupes pour la conductivité stomatale, la transpiration et l’efficacité hydrique, des caractéristiques absentes en 2011. Les effets environnementaux et liés à l’âge des feuilles étaient significatifs. Par conséquent, l’accumulation de carbone par l’intermédiaire de la photosynthèse n’explique pas en soi les différences d’accumulation de biomasse entre les génotypes ou les groupes. De manière remarquable, nous avons observé que l’un des génotypes (le génotype 18), utilisait en permanence une plus grande part de sa capacité de photosynthèse (Pn ambiante [$CO_2$] / Pn de saturation [$CO_2$], en lumière de saturation) tout au long de la saison de croissance. En outre, ce génotype 18, ainsi que les autres génotypes à croissance rapide, produisaient des petites feuilles peu consommatrices à la densité stomatale élevée. Ces caractéristiques foliaires pourraient donc servir de facteurs déterminants dans l’accumulation de biomasse, la capacité d’adaptation et l’acclimatation à l’évolution des conditions environnementales.

# RISKS and UNCERTAINTIES

**May 21, 2012**

**16:15- 18:00. Scientific Parallel Sessions 1**

# Economics of Species Change under Risk of Climate Change: A Sensitivity and (Quasi-) Option Value Analysis

Marielle BRUNETTE - INRA, LEF Nancy - France
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Climate change will imply increasing temperatures and/or changes in water regimes, so that some impacts on forest ecosystems could be expected. However, large uncertainties still characterize these impacts. Henceforth, forest management decisions should take climate change and its uncertain effects into account. Some adaptation actions are thus advocated, among them the shift to climatically more robust and/or shorter rotation species. Indeed, forest transition including more site-adapted and drought resistant deciduous tree species is presented as a major adaptation action in the forest sector. Nevertheless, several questions emerge concerning this adaptation strategy: How to consider uncertainty in the decision making process? What species must be favoured? Does the shift must be realized now or with a delay? The problem of tree species resistance to climate change was tackled from an ecological side and, to our knowledge, only few papers deal with this aspect with an economic approach (Yousoufpour et al., 2010; Hanewinkel et al., 2010). These papers do not analyse the question of timing of decisions which might be important for the analysis of adaptation of forests to climate change. Moreover, as methodology, they prioritize optimization and the Faustmann approach respectively, while methodologies specific to the economics of uncertainty should then be considered, since they allow analysing sequential decision-making in an uncertain context. In this paper, our objective is to provide economic insights of timber species change as a tool to adapt forests to climate change. As usual, we take uncertainty into account exogenously via sensitivity analysis. In addition, we consider uncertainty in an endogenous manner through (quasi)-option value calculation (Henry, 1974). This method is a useful tool in environmental economics (Fisher, 2000) but to our knowledge, it has not been used in the analysis of timber species choice. To do so, we use the framework of cost-benefit analysis. This framework is commonplace in environmental economics (Pearce et al., 2006), and it has been recommended in the analysis of adaptation options (Hallegatte et al., 2010). Our analysis is illustrated with the conversion from Norway spruce to Douglas-fir. Conditions under which species shifts make sense and optimal timing of species shifts are exhibited. We calculate the value of additional information (research), and show that it should not be neglected. Cost-effectiveness of transition options with shorter rotation species appeared especially sensitive to initial costs. We show that despite uncertainties, cost-benefit analysis provides significant insights on forest adaptation to climate change.

## Économie des changements d’essences face au risque du changement climatique : une analyse de la sensibilité et de la valeur d’(e) (quasi-)option

Le changement climatique implique une hausse des températures et/ou des changements dans les régimes hydriques, des impacts sur les écosystèmes forestiers sont donc à prévoir. De larges incertitudes continuent toutefois de planer sur ces impacts. Dorénavant, les décisions en matière de gestion forestière doivent tenir compte du changement climatique et de ses conséquences éventuelles. Certaines actions d’adaptation sont préconisées, parmi lesquelles la mutation vers des essences plus résistantes au climat et/ou à rotation plus courte. De fait, la transition des forêts, intégrant des essences d’arbres à feuillage caduc mieux adaptées aux sites et plus résistantes, est présentée comme une action d’adaptation majeure du secteur forestier. Néanmoins, cette stratégie d’adaptation soulève plusieurs questions : comment tenir compte des incertitudes dans le processus de prise de décision ? Quelles essences privilégier ? La mutation doit-elle se faire dès à présent ou à terme ? Le problème de la résistance des essences au changement climatique a été pris en compte d’un point de vue écologique et, à notre connaissance, seuls quelques articles traitent de cet aspect sous un angle économique (Yousoufpour et al., 2010 ; Hanewinkel et al., 2010). Ces articles ne traitent pas du moment opportun pour ces décisions, un aspect qui pourrait toutefois revêtir une certaine importance pour l’analyse de l’adaptation des forêts au changement climatique. Par ailleurs, en guise de méthodologie, ils priorisent respectivement l’optimisation et la méthode Faustmann, alors que des méthodologies spécifiques à l’économie d’incertitude doivent être envisagées, puisqu’elles permettent l’analyse d’une prise de décision séquentielle dans un contexte incertain. L’objectif de cette présentation est d’éclairer sous un jour économique le changement des essences d’arbres comme outil d’adaptation des forêts au changement climatique. Nous intégrons l’incertitude de manière exogène par le biais d’une analyse de la sensibilité. En outre, nous l’intégrons de manière endogène par le biais d’un calcul de valeur d’(e) (quasi-)option (Henry, 1974). Cette méthode est un outil utile en matière d’économie environnementale (Fisher, 2000) mais, à notre connaissance, elle n’est pas utilisée pour l’analyse du choix des essences de bois d’œuvre. À cette fin, nous utilisons le cadre d’analyse bénéfices-coûts. Ce cadre est répandu dans l’économie environnementale (Pearce et al., 2006), et est recommandé pour l’analyse des options d’adaptation (Hallegatte et al., 2010). Notre analyse est illustrée par la conversion de l’épicéa de Norvège au pin Douglas. La présentation précise les conditions dans lesquelles les mutations d’essences font sens ainsi que leur opportunité optimale dans le temps. Nous calculons la valeur des informations complémentaires (recherche) et prouvons qu’elle ne doit pas être négligée. La rentabilité des options de transition avec des essences à rotation plus courte est particulièrement sensible aux coûts initiaux. Nous montrons que, malgré les incertitudes, l’analyse bénéfices-coûts fournit des perspectives significatives pour l’adaptation des forêts au changement climatique.

# Addressing climate change scenarios in Eucalypt forest management. A landscape level optimization study case.

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Climate change may impact substantially the forest sector in Portugal. Several studies point out to the warming of winters and to the increase of both the length of the dry season and the frequency of extreme events. We present research aiming at assessing impacts of climate change on Eucalypt forest management planning. The proposed approach integrates a process-based model that is sensitive to environmental changes, Glob3PG, and a multi-objective optimisation model in a DSS to identify optimised management plans under changing environmental conditions. The application problem includes multiple objectives e.g. pulpwood and biomass annual flows, water resources (i.e. run-off) and net present value, subject to ending inventory. For testing purposes, a eucalyptus forest with over 1000 stands extending over 11873 ha in Portugal was considered. The test problems encompassed a 20 years temporal horizon and two climate scenarios. A mixed integer linear programming (MILP) model was developed and solved using CPLEX (ILOG CPLEX 12.1). Results demonstrated the potential of the proposed approach to provide information and insight to support landscape analysis and planning under scenarios of climate change.

## Tenir compte des scénarios de changement climatique dans la gestion des forêts d’eucalyptus. Étude de cas d’optimisation au niveau du paysage.

Le changement climatique pourrait avoir un impact important sur le secteur forestier au Portugal. Plusieurs études alertent sur le réchauffement hivernal et sur l’augmentation de la durée de la saison sèche et la fréquence des événements extrêmes. Nous présentons des recherches qui visent à évaluer les impacts du changement climatique sur la planification de la gestion forestière des eucalyptus. La méthode proposée intègre un modèle basé sur des processus qui est sensible aux changements environnementaux, Glob3PG, ainsi qu’un modèle d’optimisation multi-objectif dans un DSS pour identifier les plans de gestion optimisés dans un contexte d’évolution des conditions environnementales. Le problème d’application inclut des objectifs multiples, par ex. les flux annuels de bois à pâte et de biomasse, les ressources hydriques (c’est-à-dire les écoulements) et la valeur actualisée nette, soumise au stock de clôture. Les essais se sont appuyés sur une forêt d’eucalyptus avec plus de 1 000 peuplements s’étendant sur plus de 11 873 ha au Portugal. Les tests ont englobé un horizon temporel de 20 ans et deux scénarios climatiques. Un modèle de programmation linéaire mixte en nombres entiers a été développé et résolu à l’aide de CPLEX (ILOG CPLEX 12.1). Les résultats illustrent le potentiel de la méthode proposée pour fournir informations et perspectives afin d’éclairer l’analyse et la planification du paysage dans les scénarios de changement climatique.

## Coping with possible wildfire regime shifts under a changing climate: Need for local management in western Canada

Dr. Akira S MORI - Yokohama National University - Japan

In order to help land management and forest-based sector adapt and mitigate to the challenges of changing climate in the present and future, it is essential to have several options based on prediction scenarios to present to policy makers and managers. Few studies have focused on the benefit of basing decisions on alternative scenarios for the uncertain and complex nature of forest ecosystems at scales that are actually meaningful for local managers. Climate change may affect probability of extreme events such as wildfires. Although wildfires are one of the most important ecological processes in forest ecosystems, large-scale wildfires are sometimes perceived as an environmental catastrophe. Since failure to acknowledge the dynamic nature of ecosystems will inevitably lead to unexpected outcomes, we need to enhance our knowledge of how to cope with future intensive events coupled with climate change. Here, this study tries to infer several future scenarios in three different time periods for the Columbia Montane Cordillera Ecoprovince in Canada, which is prone to wildfires. These scenarios predict the probability of widespread wildfires based on the hierarchical Bayesian model. The model was based on relationships between wildfires and the Monthly Drought Code (MDC). The MDC is a generalized monthly version of the Daily Drought Code widely used across Canada by forest fire management agencies in the monitoring of wildfire risk. To calculate the future MDC values, this study relied on different possible future circumstances of climate, given by Special Report on Emission Scenarios of the Intergovernmental Panel on Climate Change. By drawing on this knowledge, it may be possible to mitigate climate change impacts both before they arise and once they have occurred. These considerations are critical in maintaining integrity of systems shaped by large-scale natural disturbances to increase resilience to changing climate; while at the same time protecting human society and infrastructures from devastation. This would facilitate our adaptation to climate change in managing fire-vulnerable forest ecosystems.

## Faire face aux possibles changements de régimes des incendies dans le contexte du changement climatique : besoin d'une gestion locale dans l'ouest du Canada

Afin d'aider les secteurs forestiers et liés à la gestion des terres à s'adapter et à atténuer les défis liés au changement climatique, aujourd'hui et à l'avenir, il est essentiel que plusieurs options fondées sur des scénarios prédictifs soient mises à la disposition des décisionnaires et des gestionnaires. Peu d'études se concentrent sur les bénéfices de décisions fondées sur des scénarios alternatifs – vis-à-vis de la nature incertaine et complexe des écosystèmes forestiers et naturels – à des échelles qui soient réellement significatives pour les gestionnaires locaux. Le changement climatique peut avoir un impact sur la probabilité des événements extrêmes comme les feux de forêts. Bien que ces derniers constituent l'un des processus écologiques les plus importants des écosystèmes forestiers, ils sont parfois perçus comme une catastrophe environnementale. L'échec à reconnaître la nature dynamique des écosystèmes entraîne inévitablement des issues imprévisibles, nous avons donc besoin de renforcer notre connaissance pour faire face aux prochains événements intensifs associés au changement climatique. Cette étude tente de suggérer plusieurs scénarios dans trois périodes différentes pour l'écoprovince de la cordillère de Colombie britannique au Canada, très exposée aux incendies. Ces scénarios prévoient la probabilité de feux de friches très répandus sur la base du modèle hiérarchique bayésien. Le modèle était fondé sur les relations entre les incendies et le Code de Sécheresse mensuel. Ce Code est une version mensuelle généralisée du Code de sécheresse quotidien utilisé au Canada par les agences de gestion des feux pour contrôler le risque de feux de friches. Pour calculer les futures valeurs du Code, cette étude s'est appuyée sur différentes circonstances climatiques possibles, fournies par le Rapport spécial du Groupe d'experts intergouvernemental sur l'évolution du climat (GIEC) sur les scénarios d'émissions. En s'appuyant sur ces éléments, il est possible de réduire les impacts du changement climatique avant même leur apparition et une fois qu'ils sont survenus. Ces aspects sont essentiels pour maintenir l'intégrité de systèmes fondés sur des perturbations naturelles de grande échelle et améliorer la résistance au changement climatique ; tout en protégeant en même temps la société humaine et ses infrastructures de la dévastation. Cela faciliterait notre adaptation au changement climatique en gérant les écosystèmes forestiers vulnérables au feu.

# Ecosystem Management in the Face of Uncertainty: Organisational Problem-Solving Performances of German State Forest Administrations Concerning Climate Change Adaptation Measures

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Dr., Roderich, VON DETTEN - Institute of Forestry Economics, University of Freiburg - Germany

The contradiction between the goal of long-term sustainable management of forests and the irreducible complexity and unpredictability of forest ecosystems leads to a fundamental uncertainty. Hence, the main interest of our current research project lies at the interface between ambiguous organizational decision-making in regional forestry administrations and contradictory, complex and uncertain knowledge concerning climate change adaptation. In our case study of German state forest administrations we focus on social practices of problem-solving performances and processes related to a) the organizational response of an administration confronted with heterogeneous expectations and interests from its dynamic environment (outside perspective) and b) long-term decision-making under uncertainty on the regional and local level (inside perspective). Based on qualitative (32 expert interviews with directors and heads of departments) and quantitative (online survey among district foresters) data, we argue that – instead of being considered as a hurdle for long-term planning – the acceptance of indispensable uncertainty leads to an understanding of planning as a creative process, enabling a variety of solutions. Despite a growing scientific consensus concerning long-term global warming scenarios, regional forestry administrations seem to be overburdened with the complexity and uncertainty concerning climate change adaptation measures. First, along with DiMaggio & Powell (1983), we assume that regional forestry administrations absorb uncertainty by adopting solutions (e.g. working tools such as risk maps) from other forestry administrations whose response, when faced with the same problem, is considered as legitimate within the organizational field of German forestry organizations (isomorphism). As a consequence, the selection of solutions might be too hasty – and therefore too narrow. Second, we presume that practical decision-making concerning climate change adaptation measures (e.g. tree species selection) is far from rational. Based on theoretical approaches such as bounded rationality and incrementalism, as well as on findings from organizational psychology, we understand ecosystem decision-making of forest administrations on the regional and local level as the result of a complex interplay between organizational problem-solving performances and processes, different forms of knowledge and decision-making heuristics. In our oral presentation at the conference, we would like to present first results of our empirical study. We will argue for a more ‘realistic’ interpretation of organizational decision-making under uncertainty by making visible ‘windows of opportunities’ to pragmatically reconcile climate change adaptation with the goal of long-term sustainable management of forests.

## Gestion des écosystèmes face aux incertitudes : résolution des problèmes organisationnels des administrations fédérales forestières allemandes en matière de mesures d’adaptation au changement climatique

La contradiction entre l’objectif d’une gestion forestière durable à long terme et la complexité irréductible et le caractère imprévisible des écosystèmes forestiers donne lieu à une incertitude fondamentale. Notre projet de recherche actuel porte principalement sur l’interface entre une prise de décision organisationnelle ambiguë dans les administrations forestières régionales et des connaissances contradictoires, complexes et incertaines en matière d’adaptation au changement climatique. Notre étude de cas des administrations fédérales forestières allemandes se concentre sur les pratiques sociales en matière de performances et de procédures de résolution des problèmes associés à a) la réponse des organisations d’une administration confrontée aux attentes et aux intérêts hétérogènes de son environnement dynamique (perspective externe) et b) la prise de décision à long terme dans le contexte incertain à l’échelle locale et régionale (perspective interne). Sur la base de données qualitatives (32 entretiens d’experts avec des directeurs et des responsables de départements) et quantitatives (enquête en ligne auprès des experts forestiers de district), nous affirmons que – au lieu d’être considérée comme un frein à la planification à long terme – l’acceptation du degré d’incertitude indispensable permet la compréhension de la planification comme un processus créatif qui autorise une variété de solutions. Malgré un consensus scientifique croissant autour des scénarios à long terme du changement climatique mondial, les administrations forestières régionales semblent dépassées par la complexité et l’incertitude des mesures d’adaptation. Premièrement, à l’instar de DiMaggio & Powell (1983), nous suggérons que les administrations forestières régionales absorbent l’incertitude en adoptant les solutions (par ex. des outils de travail comme les cartes de risques) d’autres administrations forestières dont la réponse, quand elles sont exposées au même problème, est considérée comme légitime dans le contexte des organisations forestières allemandes (isomorphisme). Par conséquent, la sélection des solutions peut se révéler trop hâtive – et par conséquent trop étroite. Deuxièmement, nous supposons que, dans la pratique, la prise de décision en matière de mesures d’adaptation au changement climatique (par ex. sélection des essences) est loin d’être rationnelle. Sur la base de méthodes théoriques comme la rationalité limitée ou le différentialisme, ainsi qu’en nous appuyant sur les connaissances en matière de psychologie des organisations, nous comprenons que la prise de décision en matière d’écosystèmes des administrations forestières à l’échelle régionale et locale est le fruit d’une interaction complexe entre les performances et les procédures de résolution des problèmes organisationnels, différentes formes d’heuristique de connaissances et de prise de décision. Nous aimerions profiter de la conférence pour présenter les premiers résultats de notre étude empirique. Nous plaiderons pour une interprétation plus « réaliste » de la prise de décision organisationnelle à l’aune des incertitudes en rendant visibles les « fenêtres d’opportunités » pour réconcilier dans la pratique l’adaptation au changement climatique et l’objectif d’une gestion forestière durable sur le long terme.

## Dealing with uncertainty in forest management under climate change

Dr Emina KRCMAR - University of British Columbia - Canada

Forest management under climate change is a difficult task because of the complexities and uncertainties involved. Global Climate Models (GCMs) indicate a range of possible future climatic conditions in terms of temperature and precipitation. While projections of the temperature change are typically consistent about a direction of change, significant uncertainty exists around the projected precipitation change. Given highly uncertain nature of the climate variables projections, the traditional approach of managing forests assuming the most likely climate conditions is not applicable. The decision framework we propose combines the robust planning approach for making decisions under uncertainty with a method for generating strategies under multiple criteria. In addition, the framework incorporates stakeholders' attitude toward risk associated with outcomes of forest management under climate change. Impacts of climate change is linked with forest productivity that affects rotation age, wood quality and volume, size of logs, and, consequently, the distribution of forest products and jobs. The proposed decision framework is illustrated by a management problem that addresses the stability of harvest flows over time and under climate change. Opportunities and challenges of our approach are discussed using results of a case study from British Columbia, Canada.

## Gestion des incertitudes dans la gestion forestière dans le contexte du changement climatique

La gestion forestière dans le contexte du changement climatique est une tâche difficile en raison de la complexité et des incertitudes impliquées. Les Modèles climatiques globaux fournissent une gamme de futures conditions climatiques possibles en termes de température et de précipitations. Si les tendances en matière de projections de température sont en générales cohérentes, des incertitudes significatives subsistent à l'égard des changements annoncés en matière de précipitations. Étant donné la nature très incertaine des projections de variables climatiques, la méthode traditionnelle de gestion forestière tenant compte des conditions climatiques les plus probables n'est pas applicable. Le cadre décisionnel que nous proposons associe une méthode de planification solide pour la prise de décision et une méthode d'élaboration de stratégies qui tient compte de critères multiples. En outre, ce cadre intègre l'attitude des parties prenantes face au risque, associée aux résultats de gestion forestière dans le contexte du changement climatique. Les impacts du changement climatique sont associés à la productivité des forêts, qui a un impact sur l'âge de rotation, la qualité du bois et son volume, la taille des grumes et par conséquent la distribution des produits et des emplois. Le cadre de décision proposé est illustré par un problème de gestion qui porte sur la stabilité des flux de récolte au fil du temps et dans le contexte du changement climatique. Les opportunités et défis de notre méthode sont étayés par les résultats d'une étude de cas en Colombie britannique, Canada.

## Adapting to incremental and threshold climate change impacts to forests

Jody BRUCE - CSIRO - Australia
Dr Michael BATTAGLIA - CSIRO - Australia
Dr Libby PINKARD - CSIRO – Australia
Dr Don WHITE - CSIRO - Australia

Climate change impacts to forests are often represented by incremental changes in temperature and rainfall effects on forest production. Such changes are often well accommodated by adaptive management practices typically practiced by natural resource and forest management agencies. However the recent increase in frequency and severity of forest mortality, though drought and pests, seen globally shows that climate change will also impose threshold changes to forest function and performance. Precautionary management is typically recommended in such cases where system state change for the worse markedly and where the timing and drivers of change are poorly defined. Such responses however often involve up-front cost, foregone production or investment in building system resilience. The knowledge required for these types of decisions is usually more probablistic and less prescriptive than that involved in response to incremental change. In this talk, we explore the decision making environment for forest managers, and through case studies we look at how an understanding of forest physiology embedded in forest models and couple with tools to explore uncertainty can help managers explore costs and consequences of both incremental and threshold changes arising from climate change.

## S’adapter aux impacts sur les forêts du changement climatique en matière de seuil et de progression

L’impact du changement climatique sur les forêts est souvent illustré par les effets sur la production forestière des changements graduels de température et de précipitations. De tels changements sont souvent bien pris en charge par les pratiques de gestion adaptative qu’appliquent en général les agences de gestion des ressources naturelles et des forêts. Néanmoins, la hausse récente dans la fréquence et la gravité de la mortalité des forêts, en raison de la sécheresse et des nuisibles, constatée mondialement, indique que le changement climatique va également imposer des modifications de seuil dans la fonction et la performance des forêts. Une gestion prudente est en général recommandée dans les cas où l’état du système évolue négativement de manière significative et quand le délai et les facteurs de changement sont mal définis. De telles réponses impliquent toutefois des coûts en amont, un manque à gagner ou des investissements pour consolider la résistance du système. La connaissance requise pour ce type de décisions est en général plus probabiliste et moins prescriptive que celle impliquée dans les réponses aux changements progressifs. Nous explorons ici l’environnement décisionnel pour les gestionnaires forestiers. Par le biais d’études de cas, nous étudions en quoi la compréhension de la physiologie des forêts, intégrée dans les modèles forestiers et associée à des outils pour explorer les incertitudes, peut aider les gestionnaires à explorer les coûts et les conséquences à la fois des changements de seuil et graduels provoqués par le changement climatique.

# PRODUCTIVITY, DISTRIBUTION 1

**Tuesday 22 May**

**8:30 – 10:15. Scientific Parallel Sessions 2**

## Simulated forest productivity and biomass changes under global change

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Forest productivity and biomass are crucial elements of the terrestrial carbon cycle. Process-based forest models have been widely used to project forest productivity and biomass under changing environmental conditions. However, there are different types of uncertainties associated with these studies: 1) future climate uncertainty as expressed by the choice of the climate scenarios and the underlying General and Regional Circulation Models (GCM/RCM), 2) model structural uncertainty as a consequence of different possible formulations of ecological processes, and 3) model parameter uncertainty. These uncertainties affect the reliability of model projections of future productivity and biomass changes and their usefulness for vulnerability assessments, decision-making and management. Within the MOTIVE project, we carried out a systematic literature review of stand-level, process-based simulation studies that use scenarios of climate change, atmospheric CO2-concentration, and nitrogen deposition to project forest productivity and biomass changes. We then synthesized the projected productivity shifts relative to simulated past productivity and biomass. As of the year 2010, about 50 process-based, stand-level simulation studies on forest productivity and biomass under global change are available in the Web of Science database. Most of the studies cover temperate and boreal forests in Europe and Northern America and focus on common tree species. We present a synthesis of the results of these studies in terms of 1) multi-model mean/median productivity and biomass changes for biomes, 2) individual-model mean/median productivity and biomass changes for biomes (if several runs of the same model are available), and 3) mean/median productivity and biomass shifts for changes of individual environmental drivers (e.g. per degree warming) and their combination. This approach permits capturing a wide range of climate change scenarios, model structures, and model parameters, which in turn allows for an assessment of productivity and biomass shift's uncertainties. We discuss the model results in light of their underlying model structure and model processes and compare them with measurements of past forest productivity and biomass changes. Ultimately our results show the sensitivity of forest productivity and biomass in temperate and boreal forests to CO2-fertilization effects, water availability and drought, temperature-induced increases in photosynthesis, lengthening of the vegetation period, nitrogen depositions, and interactions of these factors. Furthermore, we unravel possibilities for model enhancement, highlight key knowledge gaps for model formulations, and stress the need for model inter-comparisons and improved methods for scenario, model structure and model parameter uncertainty quantification.

## Simulation des changements de productivité et de biomasse des forêts dans le contexte du changement climatique

La productivité et la biomasse des forêts sont essentielles au cycle de carbone terrestre. Les modèles forestiers fondés sur les processus sont largement utilisés pour projeter la productivité et la biomasse des forêts à l'aune de l'évolution des conditions environnementales. Plusieurs types d'incertitudes restent toutefois associés à ces études : 1) la future incertitude climatique telle qu'exprimée par le choix des scénarios climatiques et les modèles de circulation régionale et générale (MCR/MCG) sous-jacents, 2) l'incertitude structurelle du modèle en conséquence de différentes formulations possibles des processus écologiques, et 3) l'incertitude des paramètres du modèle. Ces incertitudes ont un impact sur la fiabilité des projections des futurs changements de productivité et de biomasse ainsi que sur leur utilité dans l'évaluation de la vulnérabilité, la prise de décision et la gestion. Au sein du projet MOTIVE, nous avons mené une analyse systématique de la documentation au niveau des peuplements, des études de simulation fondées sur les processus, qui font appel aux scénarios de changement climatique, de concentration de $CO_2$ dans l'atmosphère et de dépôt d'azote, pour projeter les changements de productivité et de biomasse des forêts. Nous avons alors synthétisé les mutations projetées de productivité associées aux simulations de la productivité et de la biomasse antérieures. Depuis 2010, environ 50 études de simulation fondées sur les processus au niveau des peuplements, et portant sur la productivité et la biomasse des forêts dans le contexte du changement climatique, sont disponibles dans la base de données Web of Science. La plupart portent sur les forêts boréales et tempérées d'Europe et d'Amérique du Nord et se concentrent sur les essences d'arbres communes. Nous présentons une synthèse des résultats de ces études en termes de 1) changements de productivité et de biomasse moyenne/médiane multimodèle pour les biomes, 2) changements de productivité et de biomasse moyenne/médiane modèle individuel pour les biomes (si plusieurs traitements du même modèle sont disponibles), et 3) changements de productivité et de biomasse moyenne/médiane pour les modifications de moteurs environnementaux individuels (par ex. réchauffement par degré) et leur association. Cette méthode permet de saisir une large gamme de scénarios climatiques, de structures et de paramètres de modèle, qui à leur tour permettent une évaluation des incertitudes liées aux modifications dans la productivité et la biomasse. Nous discutons des résultats du modèle à la lumière de la structure et des processus sous-jacents du modèle et nous les comparons avec les changements antérieurs de la productivité et de la biomasse des forêts. Enfin, nos résultats illustrent la sensibilité de la productivité et de la biomasse des forêts tempérées et boréales aux effets de la fertilisation $CO_2$, de la disponibilité hydrique et de la sécheresse, des augmentations de la photosynthèse liées à la température, de l'extension de la période de végétation, des dépôts d'azote, et des interactions entre ces facteurs. Enfin, nous illustrons les possibilités d'amélioration du modèle, nous mettons en avant les principaux écarts de connaissances pour la formulation des modèles et nous soulignons le besoin de comparaisons entre modèles et la nécessité de méthodes améliorées pour l'évaluation des incertitudes liées aux scénarios et à la structure et aux paramètres des modèles.

## How will climate change affect the relationship between tree diversity and productivity in European temperate forests?

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On-going climate change affects forest functioning processes such as productivity. However climate change will also alter forest biodiversity through shifts in species distribution and changes in community composition, which in turn modifies forest productivity. Understanding the link between biodiversity and productivity and how it will be affected by climate change are thus two decisive issues, especially in the context of global biodiversity loss. The relationship between species richness and productivity has been explored widely through experiments, usually showing a positive relationship, but without being able to explain how this effect will unfold in the long-term, especially in forests. Furthermore, the impact of climate change on this relationship has been never explored in forests. We used a novel approach to study (i) the response of forest productivity to changes in tree species richness and (ii) how climate change may affect this response, employing the process-based forest succession model ForClim. First, we show that tree diversity influences productivity in European temperate forests across a wide range of climatically distinct 11 sites through a strong complementarity effect. Hence, our results confirm the positive diversity-productivity relationship found in grassland experiments, and the increasing relative importance of complementarity in comparison to selection through time. Second, we show that increasing tree diversity leads to greater stability of forest productivity over time (i.e. lower variance), mostly because of a larger asynchrony in species fluctuations when more species are present in the forest. We also show that these results are strongly influenced by functional diversity. Third, we quantify how climate change affects the relationship between diversity and productivity at the study sites by performing simulations using scenarios from three Regional Climate Models. Our study thus provides a new basis to disentangle the role of diversity as a crucial driver for productivity in forests and to make predictions about the impact of climate change on forest ecosystems.

## En quoi le changement climatique a-t-il un impact sur la relation entre la diversité des arbres et la productivité des forêts européennes tempérées ?

Le changement climatique en cours a un impact sur les processus de fonctionnement des forêts comme la productivité. Il modifie également leur biodiversité en changeant la distribution des essences et la composition des communautés, qui à leur tour influent sur la productivité des forêts. La compréhension du lien entre la biodiversité et la productivité et l'impact qu'a sur lui le changement climatique sont par conséquent deux questions décisives, particulièrement dans le contexte de la perte globale en biodiversité. La relation entre la richesse des essences et la productivité a fait l'objet d'une exploration élargie par le biais d'expériences, qui indiquent en général une relation positive, sans toutefois expliquer comment cet effet évoluera à long terme, particulièrement dans les forêts. En outre, l'impact du changement climatique sur la relation n'a jamais été étudié dans les forêts. Nous avons fait appel à une méthode innovante pour étudier (i) la réponse de la productivité des forêts aux changements apportés à la richesse des essences d'arbres et (ii) comment le changement climatique peut avoir un impact sur cette réponse, en nous appuyant sur le modèle de succession des forêts fondé sur les processus ForClim. Premièrement, nous montrons que la diversité des arbres influence la productivité des forêts européennes tempérées sur une large étendue de 11 sites distincts sur le plan climatique, par l'intermédiaire d'un effet élevé de complémentarité. Par conséquent, nos résultats confirment la relation positive diversité-productivité décelée par les expérimentations effectuées en pâturages, et l'importance relative croissante de la complémentarité en comparaison de la sélection au fil du temps. Deuxièmement, nous montrons que l'augmentation de la diversité des arbres entraîne une plus grande stabilité de la productivité des forêts avec le temps (c'est-à-dire des écarts moindres), principalement en raison d'une large asyncronie dans les fluctuations d'essences quand un plus grand nombre d'essences sont recensées dans la forêt. Nous montrons également que ces résultats sont fortement influencés par la diversité fonctionnelle. Troisièmement, nous quantifions en quoi le changement climatique a un impact sur la relation entre la diversité et la productivité sur les sites étudiés en nous appuyant sur des simulations fondées sur les scénarios de trois Modèles climatiques régionaux. Notre étude fournit ainsi une base nouvelle pour démêler le rôle de la diversité comme facteur crucial de productivité dans les forêts et pour formuler des prévisions sur l'impact du changement climatique sur les écosystèmes forestiers.

# Forest productivity shifts under climate change in Europe : a model-based analysis

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A model-based analysis of forest productivity under global change is presented for a broad set of typical forest sites in Europe. The study was performed in the framework of the EU project MOTIVE. In this analysis we applied the process-based model 4C (FORESEE) to simulate the impact of climate change and elevated atmospheric CO2 concentration under two realizations of the SRES scenario A1B and B1 respectively along major environmental gradients in Europe. The analysis focused on the forest productivity of the five most important European tree species (Scots pine (Pinus sylvestris L.), Norway spruce (Picea abies L. Karst.), European beech (Fagus sylvatica L.) and Sessile and Pedunculate oak (Quercus petraea Liebl. and Quercus robur L.) in three distinguished bioclimatic European regions (boreal, temperate and montane forests). International databases (e.g. ICP Forests, EUROFLUX) were applied that are newly available and crucial for studies simulating forest productivity under changing environmental conditions. After a validation process (see poster by Suckow et al.) a set of 131 typical forest stands all over Europe was selected from the ICP Forests Database. Daily climate data for the past and the future was interpolated to these sites. The model 4C was run for recent and future climate on all sites. The analysis of simulated Net Primary Production (NPP) under recent climate (1971-2000) showed good correspondence with results found in the literature. The sites of the temperate bioclimatic region are the most productive ones and the broadleaved forests are more productive than coniferous forests. To analyze the impacts of changing climate on forest productivity, the averaged annual NPP was considered from 2001 until 2090 for three 30-years periods, without or with including effect of elevated CO2 concentration, in comparison with the NPP of the baseline period 1971-2000. The analysis of relative change of productivity for bioclimatic regions indicates that boreal forests gain most from the assumed climate change, especially in the case of increasing CO2 concentration. Considering only the climate change effect there are only small difference in the medians of relative change rates of NPP for the boreal and temperate forests. The combined effect of climate change and CO2 concentration leads to clear higher NPP for the whole period and all bioclimatic regions. Comparing the species-specific NPP changes the results indicated that the coniferous species have the highest benefit from climate change. For the broadleaved forests the results show increasingly negative responses, especially towards the end of the century.

## Modifications de la productivité des forêts dans le contexte du changement climatique en Europe : une analyse fondée sur le modèle

Une analyse fondée sur la modèlisation de la productivité des forêts en réponse au changement climatique est ici présentée pour un large panel européen de sites forestiers types. L'étude a été effectuée dans le cadre du projet européen MOTIVE. Cette analyse s'appuie sur le modèle fondé sur les processus 4C (FORESEE) pour simuler l'impact du changement climatique et d'une concentration en $CO_2$ élevée sur des gradients environnementaux majeurs en Europe, respectivement selon deux scénarios SRES A1B et B1. L'analyse se concentre sur la productivité des cinq essences d'arbres les plus importantes en Europe (pin sylvestre (Pinus sylvestris L.), épicéa commun (Picea abies L. Karst.), hêtre européen (Fagus sylvatica L.) et chênes sessile et pédonculé (Quercus petraea Liebl. et Quercus robur L.) sur trois régions bioclimatiques européennes distinctes (forêt boréale, tempérée et de montagne). Les bases de données internationales (par ex. ICP Forests, EUROFLUX) ont été utiles ; nouvellement disponibles, elles sont essentielles pour les études qui simulent la productivité des forêts dans le contexte du changement climatique. Après une procédure de validation (cf. Suckow et al.) un échantillon de 131 peuplements forestiers types en Europe a été sélectionné dans la base de données ICP Forests. Les données climatiques quotidiennes passées et futures ont été interpolées sur ces sites. Le modèle 4C a été appliqué pour le climat futur et récent de tous les sites. L'analyse de la Production primaire nette simulée dans le climat récent (1971-2000) révèle une bonne correspondance avec les résultats fournis par la documentation. Les sites de la région bioclimatique tempérée sont les plus productifs et les forêts de feuillus sont plus productives que celles de conifères. Pour analyser l'impact du changement climatique sur la productivité des forêts, la production primaire nette moyenne annuelle a été envisagée de 2001 à 2090 pour trois périodes de 30 ans, en incluant ou en excluant l'effet d'une hausse de la concentration en $CO_2$, par rapport à la production primaire nette constatée pour la période de référence 1971-2000. L'analyse du changement relatif de productivité pour les régions bioclimatiques indique que les forêts boréales bénéficient le plus du changement climatique supposé, particulièrement dans le cas de l'augmentation de la concentration en $CO_2$. Si on ne tient compte que de l'effet du changement climatique, la différence dans les médianes de taux de changement relatifs de la production primaire nette pour les forêts boréales et tempérées est faible. L'effet combiné du changement climatique et de la concentration en $CO_2$ initie une valeur primaire nette significativement plus élevée pour l'ensemble de la période et toutes les régions bioclimatiques. La comparaison des changements de valeur primaire nette spécifiques aux essences révèle que les conifères bénéficient le plus du changement climatique. Pour les feuillus, les résultats indiquent des réponses toujours plus négatives, particulièrement vers la fin du siècle.

## Long-term growth changes in a temperate lowland region during the last century: a retrospective analysis of tree rings comparing linear and non-linear mixed modelling approaches

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Global and local environmental changes can cause important changes in forest growth with important consequences for forest management. Characterisation of forest site productivity by the use of growth curves may become problematic since the curves assume a constant productivity over time. Although effects of climate change on tree growth are expected to be more pronounced near the edge of a species range, significant change in growth of common beech (Fagus sylvatica L.) over the last century has been reported of Flanders, Belgium, and surrounding areas of European temperate lowland, where the species is situated near its climatic optimum. In this article we examined if common beech growing in the forest complexes of Meerdaalwoud-Heverleebos and Zoniënwoud-Hallerbos, situated in Flanders, Belgium shows similar long-term growth trends as described for other regions in Europe, applying both mixed linear and non-linear modelling approaches. Radial growth of common beech was characterized by an initial long-term growth increase, reaching its maximum in the second half of the 20th century, followed by a recent growth decrease. With an observed growth increase of up to 19 to 24% and an overall growth increase over the 20th century of 12 to 18%, the observed long-term changes are very similar to the changes described in other studies. Most confident results were achieved modelling basal area increment with a linear mixed model approach. Despite the higher flexibility of the non-linear mixed modelling approach, the technique could only detect a quadratic long-term growth trend after inclusion of a sufficiently young generation of trees.

# Changements de croissance à long terme dans une zone tempérée de faible altitude au siècle dernier : analyse rétrospective des anneaux de croissance en comparant les méthodes de modélisation mixte linéaire et non linéaire

Les changements environnementaux locaux et globaux peuvent entraîner des modifications importantes de la croissance des forêts avec des conséquences importantes pour leur gestion. La caractérisation de la productivité des sites forestiers par l'utilisation de courbes de croissance peut poser problème car celles-ci supposent une productivité constante au fil du temps. Bien que les effets du changement climatique sur la croissance des arbres devraient être plus prononcés à la limite de l'aire de distribution d'une essence d'arbres, au siècle dernier, des changements significatifs dans la croissance du hêtre (Fagus sylvatica L.) ont été signalés dans la région Flandres en Belgique et dans les régions environnantes des zones tempérées de faible altitude, à proximité de l'optimum climatique de l'essence. Cette présentation analyse si la croissance du hêtre commun qui pousse dans les espaces boisés de Meerdaalwoud-Heverleebos et Zoniënwoud-Hallerbos, dans la région Flandres en Belgique, révèle des tendances de croissance à long terme similaires à celles décrites par d'autres régions en Europe, en appliquant à la fois les méthodes de modélisation mixte linéaire et non linéaire. La croissance radiale du hêtre se caractérise par une augmentation initiale de la croissance à long terme, qui atteint son apogée dans la seconde moitié du XXe siècle, suivie par une récente diminution de la croissance. Avec une augmentation observée de la croissance de 19 à 24 % et une augmentation globale de la croissance au XXe siècle de 12 à 18 %, les changements à long terme observés sont très similaires à ceux décrits dans les autres études. La plupart des résultats fiables ont été obtenus en modélisant l'accroissement de la surface terrière par le biais d'une méthode mixte linéaire. Malgré la grande flexibilité offerte par la méthode de modélisation mixte non linéaire, la technique n'a pu déceler qu'une tendance de croissance à long terme quadratique après inclusion d'une génération d'arbres suffisamment jeunes.

# Did South Western European tree species shift upward during the last decade?

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Recent phylogeographic and genetic studies evidenced examples of tree migrations under Quaternary climate changes. However, the current climate change occurs faster than the past climate ones. Therefore a critical issue is to assess the ability of tree species to track these changes. The objectives of this work were to examine and quantify potential altitudinal shifts in tree species distributions over the last decade in response to global change. We analysed presence and absence data from the second and third surveys of the Spanish Forest Inventory. Altitudinal distribution models were fitted for five tree species (two Temperate species: Fagus sylvatica and Quercus petraea, one Sub-mediterranean species: Quercus faginea and two Mediterranean species: Quercus suber and Quercus ilex) in two mountain ranges: the Pyrenees and the Iberian System, located in the Northern and Central part of Spain, respectively. The species distribution shift was defined as the difference between the optimum altitude between the two surveys for each species and mountain range. Our results showed that half of the species presented skewed distributions and required the use of an asymmetric HOF V model (Huisman et al, 1993) to estimate the optimum altitude and thus the altitudinal shift without bias. According to the species and the mountain, shifts generally ranged between -34 and + 36 m. The Mediterranean species found at the core of their latitudinal distribution range presented the smallest shifts. For the Temperate and Sub-mediterranean oak species, the patterns were varying according to the species and the mountain: Q. petraea exhibited a large upward shift of 181 m in the Iberian System between the two surveys and a moderate 36 m shift in the Pyrenees Mountains. Q. faginea was the only species that presented a significant shift of 93 m in the Pyrenees Mountains. This work highlighted the existence of species- and region-specific changes in the altitudinal optimum of tree species over a 10 year-long time period in response to global change. The species responses were interestingly different depending on the relative position of the species compared to the core of their climatic range.
Huisman, J., Olff, H. & Fresco, L. F. M. (1993) A Hierarchical Set of Models for Species Response Analysis. Journal of Vegetation Science, 4, 37-46.

## Les essences d'arbres d'Europe méridionale occidentale ont-elles connu une élévation en altitude au cours de la dernière décennie ?

Les récentes études phylogéographiques et génétiques ont mis en avant des exemples de migrations d'arbres lors des changements climatiques constatés au Quaternaire. Néanmoins, le changement climatique actuel se déroule plus rapidement que les précédents. L'évaluation de la capacité des essences d'arbres à suivre le rythme de ces changements est donc essentielle. Ce travail avait pour objectif d'examiner et de quantifier les migrations altitudinales potentielles de la distribution des essences d'arbres sur la dernière décade en réponse au changement climatique. Nous avons analysé les données de présence et d'absence des deuxième et troisième inventaires de l'Office espagnol des forêts. Les modèles de distribution altitudinale ont été mis en place pour cinq essences d'arbres (deux essences tempérées : Fagus sylvatica et Quercus petraea, une essence subméditerranéenne : Quercus faginea et deux essences méditerranéennes : Quercus suber et Quercus ilex) sur deux chaînes de montagnes : les Pyrénées et le Système ibérique, situés respectivement dans le nord et dans le centre de l'Espagne. La migration de la distribution des essences a été définie comme la différence entre l'altitude optimale entre les deux inventaires pour chaque essence et chaque chaîne de montagnes. Nos résultats indiquent que la moitié des essences ont présenté des répartitions biaisées et nécessitaient l'utilisation d'un modèle asymétrique HOF V (Huisman et al, 1993) pour évaluer correctement l'altitude optimale et ainsi la migration altitudinale. En fonction des essences et de la montagne considérée, les migrations s'étendaient généralement entre -34 and + 36 m. Les essences méditerranéennes recensées au cœur de leur étendue de répartition latitudinale présentaient les migrations les plus faibles. Pour les essences de chênes tempérées et subméditerranéennes, les schémas varient en fonction de l'essence et de la montagne : Q. petraea affiche une large migration vers le haut de 181 m dans le Système ibérique entre les deux études et une migration modérée de 36 m dans les Pyrénées. Q. faginea est la seule essence à présenter une migration significative de 93 m dans les Pyrénées. Le travail met en avant l'existence de changements d'altitude optimale spécifiques aux régions et aux essences sur une période de dix ans en réponse au changement climatique. La réponse des essences se distingue remarquablement en fonction de leur position relative par rapport au cœur de leur étendue climatique.

Huisman, J., Olff, H. & Fresco, L. F. M. (1993) Arsenal de modèles hiérarchiques pour l'analyse de la réponse des essences/A Hierarchical Set of Models for Species Response Analysis. Journal of Vegetation Science, 4, 37-46.

## Spatiotemporal prediction of site-productivity in Baden-Württemberg

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An approach is presented for spatiotemporal prediction of site-productivity in the context of climate change in German state of Baden-Württemberg. To model dominant height growth we apply repeated measurements on sample plots from German national forest inventory and from enterprise-level inventories. Site-index, the dominant height at reference age, is modeled dependent on retrospective climate data, and is then predicted by means of climate prognosis data. Retrospective climate data are derived from predictions of the Global Forecast System (GFS) using NCEP/NCAR reanalysis data, which were downscaled via the Weather Research & Forecasting Model (WRF). Final regionalization of climatic variables on 50 m x 50 m grid resolution is based on geomorphologic information and recordings from weather stations of Germany's National Meteorological Service (Deutscher Wetterdienst, DWD). As Climate prognoses data we use data from the regional climate model REMO based on the global circulation model ECHAM5-/MPI-OM and common IPCC-scenarios. Regionalization techniques were implemented in SAGA-GIS modules. Spatiotemporal site-index predictions are derived by a universal kriging approach with sparse spatial covariance functions, and where regionalized climate variables and spatiotemporal predictions of soil moisture are used as covariates in smooth linear predictor functions.

## Prédiction spatiotemporelle de la productivité des sites en Bade-Wurtemberg

Une méthode de prédiction spatiotemporelle de la productivité des sations dans le contexte du changement climatique dans l’état allemand du Bade-Wurtemberg est présentée. Pour modéliser la croissance en hauteur dominante, nous appliquons des mesures répétées sur les parcelles d’échantillon de l’Office fédéral allemand des forêts et sur des stocks à l’échelle des entreprises forestières. L’indice de station – la hauteur dominante à l’âge de référence – est modélisé en fonction des données climatiques rétrospectives, puis prédit par le biais des données des pronostics climatiques. Les données climatiques rétrospectives sont dérivées des prédictions du Global Forecast System (GFS) qui s’appuie sur les données de réanalyse NCEP/NCAR, ramenées à l’échelle locale par le biais du modèle Weather Research & Forecasting (WRF). La régionalisation finale des variables climatiques sur une grille de résolution 50 m x 50 m se fonde sur les informations géomorphologiques et les enregistrements des stations météo du Service météorologique national allemand (Deutscher Wetterdienst, DWD). Pour les données de pronostics climatique, nous nous appuyons sur les données du modèle climatique régional REMO fondé sur le modèle de circulation globale ECHAM5-/MPI-OM et sur les scénarios communs GIEC. Les techniques de régionalisation ont été mises en œuvre dans les modules SAGA-GIS. Les prédictions spatiotemporelles d’indice de station sont dérivées par une méthode de krigeage universel avec des fonctions de covariance spatiale clairsemées, et où les variables climatiques régionalisées et les prédictions spatiotemporelles d’humidité du sol servent de covariantes dans des fonctions prédictives linéaires lissées.

# RESILIENCE 2

**Tuesday 22 May**

**8:30 – 10:15. Scientific Parallel Sessions 2**

# Adaptability of silver birch (*Betula pendula* Roth) to elevated temperature and changing water regime

Mikko J. ANTTONEN - Finnish Forest Research Institute - Finland
Boy J.H.M. POSSEN - Finnish Forest Research Institute – Finland
Elina OKSANEN - University of Eastern Finland – Finland
Ülo NIINEMETZ - Estonian University of Life Sciences – Estonia
Elina VAPAAVUORI - Finnish Forest Research Institute – Finland

Predicted climate change holds challenges for long lived forest trees. For example in Finland, drought stress combined with heat spells and uneven precipitations during the growing season are predicted. Thus, genotypic variability and phenotypic plasticity are key factors for species survival. Differences in growth between individuals within a species over a number of years provide a clue as to how well individual genotypes are adapted to the current conditions or how well they can tolerate adverse conditions. On the other hand, this can be an indicator of the ability to adapt in changing environmental conditions. In our project we aim to increase understanding of the genetic variation in adaptability. For our experiments we exploit Silver birch (Betula pendula Roth) genotypes that were randomly selected from a naturally regenerated birch stand in Punkaharju, Finland (61º48’ N, 29º18’ E). The genotypes were cloned and planted in a common garden experiment in 1999. During a thinning harvest in 2008 large variation in the above ground biomass was observed between the genotypes. We reason that after 9 years of field growth the observed large variation in above-ground biomass between the genotypes gives a strong signal of their adaptability to changing growing conditions. To test this hypothesis, eleven genotypes were chosen for a controlled two year pot experiment, established in 2011, to study in detail their responses to ambient and elevated temperature (+1˚ C) in combination with three different water regimens (drought, optimal and excess). During the first year of the experiment plants were measured and samples were collected before starting the watering treatment, during the transfer phase, after 5 weeks of treatment, and 2 weeks after returning to normal watering. We measured tree growth (height and diameter increment) and several leaf parameters (gas exchange, water potential, chlorophyll, fluorescence, volatile compounds, fresh and dry weight, area, thickness, stomatal number and trichome densities). Samples were collected for gene expression, biochemical and metabolite analyses. In addition, conductance, chlorophyll and fluorescence were measured weekly during the whole experiment. At the end of the growing season 2 replicate trees of each genotype within all treatments were harvested for total leaf area and biomass analyses. Measurements during the summer 2011 have revealed many differences between genotypes. Analysis of leaf samples, and data from the next growing season, will help us to understand mechanisms behind growth differences which might be important for survival in changing environment.

# Capacité d'adaptation du bouleau blanc (*Betula pendula* Roth) aux températures élevées et à l'évolution du régime hydrique

Le changement climatique annoncé représente des défis pour les arbres forestiers à grande longévité. En Finlande par exemple, sécheresse, pics de chaleur et précipitations inégales pendant la saison de croissance sont annoncés. La variabilité génotypique et la plasticité phénotypique sont par conséquent des facteurs clés pour la survie des essences. Les différences de croissance entre les spécimens d'une même essence sur plusieurs années renseignent sur la capacité d'adaptation des génotypes individuels aux conditions actuelles ou sur leur degré de tolérance aux conditions défavorables. D'un autre côté, elles peuvent servir d'indicateur de la capacité d'adaptation à l'évolution des conditions environnementales. Notre projet a pour objectif d'améliorer la compréhension de la variation génétique dans la capacité d'adaptation. Par nos expériences, nous exploitons les génotypes de bouleau blanc (Betula pendula Roth) sélectionnés de manière aléatoire sur un peuplement naturellement régénéré de Punkaharju, en Finlande (61º48' N, 29º18' E). Les génotypes ont été clonés et plantés dans un jardin expérimental en 1999. Lors d'une coupe d'éclaircie en 2008, d'importants écarts dans la biomasse de surface ont été observés selon les génotypes. Nous sommes d'avis qu'au terme de 9 ans de croissance sur le terrain, les écarts importants observés dans la biomasse de surface entre les génotypes renseignent fortement sur leur capacité d'adaptation à l'évolution des conditions de croissance. Pour éprouver cette hypothèse, onze génotypes ont été sélectionnés pour une expérimentation contrôlée de deux ans en pot, établie en 2011, afin d'étudier en détail leur réponse aux températures ambiantes et élevées (+1˚ C) associées à trois différents régimes hydriques (sécheresse, optimal et excès). Au cours de la première année, les plantes ont été quantifiées et des échantillons prélevés avant le lancement du traitement hydrique, pendant la phase de transfert, après 5 semaines de traitement et 2 semaines après le retour à un régime hydrique normal. Nous avons évalué la croissance de l'arbre (hauteur et diamètre) et sept paramètres foliaires (échanges gazeux, potentiel hydrique, chlorophylle, fluorescence, composés volatiles, poids frais et séché, superficie, épaisseur, nombre stomatal et densité des trichomes). Des échantillons ont été prélevés pour analyse génétique, biochimique et métabolite. En outre, la conductivité, la chlorophylle et la fluorescence ont été évaluées chaque semaine pendant toute la durée de l'expérimentation. Au terme de la saison de croissance, 2 arbres répliqués de chaque génotype au sein de tous les traitements ont été collectés pour une analyse de la biomasse et de la superficie foliaire totale. Les évaluations effectuées au cours de l'été 2011 ont révélé de nombreuses différences entre les génotypes. L'analyse des échantillons de feuilles, et les données de la prochaine saison de croissance, nous aideront à comprendre les mécanismes à l'œuvre derrière les différences de croissance qui pourraient s'avérer utiles pour la survie dans un environnement évolutif.

## Structural acclimation and photosynthesis of tree canopy in changed climate

Dr. Mikko PELTONIEMI - Finnish Forest Research Institute - Finland
Dr. Remko DUURSMA - University of Western Sydney - Australia
Dr. Belinda MEDLYN - Macquarie University - Australia

It is currently unclear how the acclimation of plant structure will influence growth of plants under changed climate. Optimal models can be used to study the role of plastic changes in plant structure to climate change. These models generally maximize some proxy for fitness, such as plant photosynthesis, by optimizing the allocation of resources within plant structure. To investigate the role of structural acclimation on tree photosynthesis under changed climate, we constructed a simple optimisation model of tree canopy. The model accounts for two important structural features of plants, the foliar nitrogen content, which influences the photosynthetic rates, and hydraulic conductance, which influences the transpiration rates of the leaves. Using our model and optimisation principle, we investigated the relationship between hydraulic constraints and leaf N allocation, and estimated how the acclimation of these features will influence plant photosynthesis in future. We found out that structural features of canopies are nearly unchanged under elevated $CO_2$ and changed climate, rather they are determined by irradiance received by the leaves in the canopy. We also predict that despite of possible changes in N availability, plant structural features should remain unaltered.

# Acclimatation structurelle et photosynthèse de la canopée en climat modifié

En quoi l’acclimatation de la structure des plantes à la modification du climat aura une influence sur leur croissance reste pour l’heure une question floue. Les modèles optimaux peuvent servir à étudier le rôle des changements plastiques dans la structure des plantes. Ces modèles maximisent en général quelques données indirectes de la valeur d’adaptation, comme la photosynthèse, en optimisant l’attribution des ressources au sein de la structure des plantes. Pour étudier le rôle de l’acclimatation structurelle sur la photosynthèse des arbres sous climat modifié, nous avons élaboré un modèle d’optimisation simple de la canopée. Celui-ci tient compte de deux aspects structurels importants, la teneur foliaire en azote, qui a une influence sur les taux de photosynthèse, et la conductivité hydrique, qui a une influence sur le taux de transpiration foliaire. Notre modèle et notre principe d’optimisation nous servent à étudier la relation entre les contraintes hydrauliques et l’attribution foliaire en azote, et à évaluer comment l’acclimatation de ces aspects aura une influence sur la photosynthèse à l’avenir. Nous avons découvert que les aspects structurels de la canopée restent quasi inchangés sous un climat à plus forte teneur en $CO_2$. Ils sont plutôt déterminés par la lumière reçue par les feuilles dans la canopée. Nous prévoyons également que, malgré les changements éventuels de disponibilité en azote, les aspects structurels des plantes devraient rester inchangés.

## Mechanisms of local adaptation to climatic gradients: lessons from a Physio-Demo-Genetics Model

Dr Sylvie ODDOU-MURATORIO - INRA - France
Dr Hendrik DAVI - INRA - France

Species distribution models predict a wholesale redistribution of trees in the next century, raising two complementary issues: how migration can allow populations to spatially track their climatic niche and how quickly local tree populations can evolutionarily adapt to future climates. While it is clear that the velocity of climate change far exceeds tree migratory abilities, the issue of their evolutionary potential remains largely unresolved. The adaptability of forest trees to environmental changes is generally thought to be important due to high levels of genetic diversity and gene flow, but it can also be slowed down by long generation times and low mortality of established trees. Moreover, the use of model to integrate these different processes is hampered by the fact that theoretical models dealing with local adaptation rarely account for complex interactions among genes or functional traits regarding selection when environment or demography are unstable. In the context of increasing interest for short term evolution in non-equilibrium populations, we developed a new hybrid model on CAPSIS platform. The model couples a physical and physiological module simulating the tree response to environmental variations, a demographic module converting tree reserves into seed productions and tree mortality and modelling migration and a quantitative genetics model relating genotype to phenotype. In such frameworks, individual fitness dynamically results from the physiological and demographic processes and environment that can vary in space or in time. We apply this model on Fagus sylvatica colonisation along an altitudinal gradient in South East of France across 5 generations for two functional traits: water use efficiency (WUE) and date of budburst. We study the interplay between local adaptation, plasticity and gene flow in the response of tree populations to the altitudinal environmental variation by simulating evolutionary trajectories over five generations under stable climate. First, the model reproduces well variations of tree growth, budburst date, and seed production with elevation and between years. Second, we show that few generations are enough for natural selection to handle genetic and phenotypic differentiations for the WUE and date of budburst across the altitudinal gradient. Third, the simulated patterns of phenotypic and genotypic variations are not linear: (1) population evolved towards increased WUE only at lower elevations; (2) earlier budburst dates are selected for when elevation increases, but above a given elevation, later budburst dates are selected for due to exponential increase in late frost days.

## Mécanismes d’adaptation locale aux gradients climatiques : enseignements d’un modèle physio-démo-génétique

Les modèles de distribution des essences prévoient une redistribution globale des arbres au cours du siècle prochain, un phénomène qui soulève deux questions complémentaires : comment la migration peut-elle permettre aux populations de suivre spatialement leur niche climatique et avec quelle rapidité les populations d’arbres locales peuvent-elles évoluer pour s’adapter aux futurs climats. S’il est clair que la rapidité du changement climatique excède de loin les capacités migratoires des arbres, la question de leur potentiel d’évolution reste largement en suspens. La capacité d’adaptation des arbres forestiers aux changements environnementaux est en général considérée comme importante en raison des degrés élevés de diversité génétique et de flux génétiques, mais elle peut également être ralentie par des durées élevées de régénération et une faible mortalité des arbres établis. En outre, l’utilisation de modèles pour intégrer ces différents processus est entravée par le fait que les modèles théoriques qui traitent de l’adaptation locale tiennent rarement compte des interactions complexes entre les gènes ou les caractéristiques fonctionnelles en matière de sélection quand l’environnement ou la démographie sont instables. Dans le contexte d’intérêt croissant pour l’évolution à court terme des populations non équilibrées, nous avons développé un nouveau modèle hybride sur la plate-forme CAPSIS. Ce modèle associe un module physiologique et physique qui simule la réponse des arbres aux variations environnementales et un module démographique qui convertit les réserves des arbres en production de graines et en mortalité – tout en modélisant la migration –, et un modèle génétique quantitatif qui relie le génotype au phénotype. Dans ces cadres, la valeur d’adaptation individuelle résulte de manière dynamique des processus physiologiques et démographiques et de l’environnement qui peuvent varier dans l’espace et dans le temps. Nous appliquons ce modèle sur la colonisation de Fagus sylvatica le long d’un gradient altitudinal dans le sud-est de la France sur cinq générations pour deux caractéristiques fonctionnelles : l’efficience d’utilisationde l’eau et la date de débourrement. Nous étudions l’interaction entre l’adaptation locale, la plasticité et les flux génétiques dans la réponse des populations d’arbres à la variation altitudinale environnementale en simulant des trajectoires d’évolution sur cinq générations sous climat stable. Premièrement, le modèle reproduit efficacement les écarts de croissance des arbres, de date de débourrement et de production de graines avec l’élévation et entre les années. Deuxièmement, nous montrons que quelques générations sont suffisantes pour que la sélection naturelle gère les différenciations génétiques et phénotypiques d’efficacité hydrique et de date de débourrement le long du gradient altitudinal. Troisièmement, les schémas simulés de variations phénotypiques et génotypiques ne sont pas linéaires : (1) la population a évolué vers une augmentation de l’efficacité hydrique seulement sur les élévations les plus faibles ; (2) des dates de débourrement plus précoces sont sélectionnées quand l’élévation augmente ; mais au-delà d’une élévation donnée, des dates de débourrement tardives sont sélectionnées pour une éclosion exponentielle hors des gelées tardives.

# Can we rely on nature's spontaneity in the light of climate change predictions?

Prof. Csaba MÁTYÁS - University of West Hungary, Faculty of Forestry, Sopron, Institute of Environmental and Earth Sciences, NEESPI Focus Research Center on Non-boreal Southeast Europe - Hungary

With regard to predicted climate scenarios, the main question addressed to ecologists and forest geneticists is whether adaptive potential and the effect of natural processes such as migration, gene flow and natural selection will be sufficient to balance environmental changes. According to rather optimist views, adaptive capacity of forest trees has been sufficiently adjusted by evolution during past geological epochs of Earth's history. No doubt, compared to other life forms, the genetic system and diversity of trees is unique and their plasticity is high. Postglacial history of migration proves that trees were able to follow climatic shifts. The analysis of long-term and more recent paleoclimates of the temperate zone show that historical fluctuations are quite comparable with scenarios predicted for this century. Related to periodic grand average, the fluctuation of annual mean temperatures for the last 100 thousand years was in the order of magnitude between -8 and +2 °C, and for the recent 1000 years between – 0.6 and +0.5 °C in Central Europe. The most important thermal factor for forests, mean summer temperature is at the same time expected to rise by 2.5 – 4 °C in this century, depending on scenario type and region. While these predictions are accompanied by relatively mild increases of summer precipitation in North Eurasia, in South Europe and the Mediterranean a decrease of up to 24% is anticipated. Especially in subhumid zones, close to the xeric limits of forests, this leads to increasing impacts of drought years, the frequency of which is projected to grow by over 40% in Southern Europe. Temperature increase is driving a rapid upward range shift of species in mountains. Altitudinal range retreat is however surpassed by 3 magnitudes by latitudinal (south-north). A projected temperature increase of 4 °C is equivalent to a latitudinal shift of over 500 km. With the observed postglacial migration speed of forest trees, up to 50 km/century, this distance would require 1000 years to cover. It seems obvious that spontaneous processes cannot cope with these shifts without human support. While genetic tests prove the drastic decrease of vitality of species close to the xeric limits, at the same time, reports on observed latitudinal range retractions are sparse. There are climatic, biological, genetic, anthropogenic and methodological explanations for this discrepancy. Due to the projected negative impacts across wide areas of the range of species, the investigation of range retractions should become a priority in forest ecology and biogeography.

## Pouvons-nous nous appuyer sur la spontanéité de la nature à l'aune du changement climatique annoncé ?

En ce qui concerne les scénarios de climat projetés, la principale question adressée aux écologistes et aux généticiens des forêts est : le potentiel d'adaptation et l'effet des processus naturels comme la migration, les flux génétiques et la sélection naturelle suffiront-ils à compenser le changement climatique ? Selon des vues plutôt optimistes, la capacité adaptative des arbres forestiers a été suffisamment ajustée par l'évolution au cours des dernières époques géologiques de l'histoire de la planète. Nul doute que, comparés aux autres formes de vie, le système génétique et la diversité des arbres sont uniques et leur plasticité élevée. L'histoire postglaciaire de la migration prouve que les arbres ont été en mesure de suivre les mutations climatiques. L'analyse des paléoclimats anciens et plus récents de la zone tempérée montre que les fluctuations historiques sont relativement comparables avec les scénarios annoncés pour le siècle qui vient. Par rapport à la moyenne périodique, la fluctuation des températures moyennes annuelles pour les derniers cent milliers d'années a été de l'ordre d'une amplitude comprise entre -8 et +2 °C, et pour les 1 000 dernières années entre – 0,6 et +0,5 °C en Europe centrale. Le facteur thermique le plus important pour les forêts, la température estivale moyenne, devrait dans un même temps augmenter de 2,5 - 4 °C au cours du siècle qui vient, en fonction du type de scénario et de la région. Si ces prédictions s'accompagnent d'augmentations relativement modérées des précipitations estivales en Eurasie du Nord, les régions d'Europe du Sud et méditerranéennes pourraient subir une baisse allant jusqu'à 24 %. Particulièrement dans les zones subhumides, proches des lisières arides des forêts, ce constat implique une augmentation de l'impact des années de sécheresse, dont la fréquence pourrait croître de plus de 40 % en Europe du Sud. L'augmentation des températures entraîne une migration rapide de l'étendue des essences d'arbres vers le haut dans les montagnes. Le repli altitudinal de l'étendue est toutefois surpassé de 3 magnitudes par le repli latitudinal (Sud-Nord). Une augmentation prévue de la température de 4 °C correspond à une migration latitudinale de plus de 500 km. Compte tenu de la vitesse de migration postglaciaire observée des arbres forestiers, jusqu'à 50 km/siècle, couvrir cette distance nécessiterait un millénaire. De toute évidence, les procédures spontanées ne peuvent pas faire face à ces mutations sans le soutien de l'homme. Si les tests génétiques confirment la baisse drastique de la vitalité des essences proches des limites arides, dans un même temps, les rapports sur les replis observés d'étendue latitudinale sont rares. Des raisons climatiques, biologiques, génétiques, anthropogéniques et méthodologiques expliquent cette contradiction. En raison des impacts négatifs projetés sur de larges zones de l'étendue des essences, l'étude de ces replis doit devenir prioritaire dans l'écologie et la biogéographie forestières.

**Trends in the natural regeneration patterns of beech and silver fir in the Eastern Carpathians (Romania) under the climate change and Forest management**

Dr. Ion BARBU - Forest Research Institute - Romania
Dr.Catalina BARBU - Faculty of Forestry Uni.Suceava – Romania

Carpathian Forests are dominated by beech forests in south and west and by spruce and fir in the north. Until the end of 19th century most of the forests were primeval forests because of low density of population (< 10 inh/km2) and lack of accessibility. The study is located in the internal area of Eastern Carpathians at 800-1400 m in Dorna Basin (80,000 hectares). Based on the inventories made in 15 transects with 90 plots installed in mature forest, were estimated for each tree species the participation in the old stand and in natural regeneration strata. Statistic analysis of data put in evidence the main trends in the dynamic of composition of regeneration of stands in relation with the following factors : i. composition of mature stand; ii. altitude; iii. slope orientation; iv. slope inclination; v. age, structural type and density of the old stand. Using GIS methods and multiple regressions were developed maps of distributions of tree species in the natural regeneration. Beech and fir shows increase in comparison with spruce which is dominant in the forests. Role of beech for the increase of biodiversity and resilience of the spruce stands to disturbing factors is well known. Using the natural regeneration patterns observed in the last decades, the foresters obtain better results with lower costs for the future stands.

## Evolution de la distribution de régénération naturelle du hêtre et de sapin blanc dans les Carpates orientales (Roumanie) dans le contexte du changement climatique et gestion forestière

Les forêts des Carpates sont dominées par des hêtraies au Sud et à l'Ouest et par l'épicéa et le sapin au Nord. Jusqu'à la fin du XIXe siècle, la plupart étaient des forêts primitives en raison de la faible densité de population (< 10 h/km$^2$) et de l'accessibilité restreinte. L'étude se situe dans la région interne des Carpates orientales à 800-1400 m d'altitude dans le bassin de Dorna (80 000 hectares). Sur la base des inventaires établis sur 15 transects avec 90 parcelles installées dans des forêts matures, nous avons établi pour chaque essence d'arbre la participation dans l'ancien peuplement et dans les couches de régénération naturelle. L'analyse statistique des données a mis en évidence les principales tendances dans la dynamique de composition de la régénération des peuplements en lien avec les facteurs suivants : i. composition du peuplement mature ; ii. altitude ; iii. orientation; iv. inclinaison; v. âge, type structurel et densité de l'ancien peuplement. À l'aide des méthodes GIS et de régressions multiples, nous avons développé des cartes de distribution des essences dans la régénération naturelle. Le hêtre et le sapin affichent une hausse par rapport à l'épicéa, pourtant dominant dans les forêts. Le rôle du hêtre dans l'amélioration de la biodiversité et la résistance des peuplements d'épicéa aux facteurs de perturbations sont bien connus. En utilisant les distributions de régénération naturelle observées dans les dernières décades, les forestiers obtiennent de meilleurs résultats avec des coûts inférieurs pour les futurs peuplements.

# ECOSYSTEM SERVICES

**Tuesday 22 May**

**8:30 – 10:15. Scientific Parallel Sessions 2**

# Overestimation in the sensitivity of soil respiration to climate change throughout the mid-latitudes

Mr, Callum, BERRIDGE - Vrije Universiteit - Netherlands
Prof., Han, DOLMAN - Vrije Universiteit – Netherlands

The terrestrial biosphere annually respires an order of magnitude more carbon than all anthropogenic emissions. Current theory relates this flux exponentially to temperature, leading to the concern that increases in global mean temperatures will significantly increase terrestrial carbon emissions from soils; a positive climate feedback. The present study utilizes a collection of independently sampled site measurements taken throughout mid-latitude forest sites to show the absence of a temperature dependence of respiration at the regional scale. These findings do not refute the well-established influence temperature is proven to have on respiration; instead, they highlight a hierarchy of controls that are scale-dependent. Indeed, a further key finding is the strong and highly significant correlation found between precipitation and respiration, especially at moderate temperatures ($r2 = 0.6$, $p < 0.05$). The significance of these findings is set in context by illustrating a strong positive correlation ($r2 = 0.88$, $p < 0.001$) between gross primary productivity (GPP) and total ecosystem respiration (TER) in the absence of any correlation between GPP and soil respiration (Rs). That GPP and Rs do not respond equally to the same drivers necessitates an understanding of what drives soil respiration in order to more accurately resolve the temperate carbon balance.

## Surestimation de la sensibilité de la respiration du sol au changement climatique dans les latitudes intermédiaires

La biosphère terrestre respire annuellement une amplitude de carbone supérieure à toutes les émissions anthropogéniques. Les théories actuelles associent ce flux de manière exponentielle à la température : l'augmentation des températures moyennes de la planète pourrait augmenter considérablement les émissions carbone des sols, un phénomène source de préoccupation. Cette étude s'appuie sur un ensemble de mesures collectées indépendamment sur des sites forestiers situés en latitudes intermédiaires pour montrer l'absence de dépendance à la température de la respiration à l'échelle régionale. Ces découvertes ne réfutent pas l'influence établie de la température sur la respiration. Elles soulignent au contraire une hiérarchie des contrôles qui sont dépendants de l'échelle. De fait, une corrélation forte et solide existe entre les précipitations et la respiration, particulièrement à des températures modérées ($r2 = 0,6$, $p < 0,05$). La signification de ces résultats est remise en contexte en illustrant une forte corrélation positive ($r2 = 0,88$, $p < 0,001$) entre la Productivité primaire brute (PPB) et la respiration totale de l'écosystème en l'absence de toute corrélation entre la PPB et la respiration des sols (Rs). Que la PPB et la Rs ne répondent pas de la même manière aux même facteurs nécessite une compréhension de ce qui initie la respiration des sols afin de résoudre de manière plus efficace l'équilibre carbone tempéré.

## Assessment of cork production in new Quercus suber plantations under future climate

Joana, AMARAL PAULO - Centro de Estudos Florestais; Instituto Superior de Agronomia – Portugal
João, NUNES PALMA - Centro de Estudos Florestais; Instituto Superior de Agronomia - Portugal
Margarida, TOMÉ - Centro de Estudos Florestais; Instituto Superior de Agronomia - Portugal

Annual cork growth is known to be related to climate conditions, namely fall and winter precipitation. Most of the existing climate scenarios suggest a decrease in precipitation for Portugal, and this may have an impact for the tree growth rates, the tree cork production, and consequently in the cork debarking rotation periods used in current forest management. Currently no existing process-based model includes a module related to cork growth and cork production. Equations to predict cork growth and production were added to the parameter-sparse Yield-SAFE model which has recently been calibrated for cork oak in Portugal. The equations to predict cork production are dependent of the tree size (namely tree diameter), and this is determined by tree growth which is driven by climate variables. The study was made considering two new stands, planted after 1990, that have been installed with high stocking densities. This characteristic will tend to originate stands with higher number of trees per hectare in the future, but uncertainty remains on the resulting cork production as this is related to light and water resource availability, in particular water, the main limiting resource for most of the current cork oak stands. Simulations for the next 40 years were made for two stands. The stands are located one in the interior and one near the coast line. Both installed in 1992 with similar tree spacing distances, have different soil types, and are both now starting to be debarked for the first time. Projections allowing the comparison of current and future climate are made allowing the understanding of climate impact on tree growth, its cork production and suggestions on adaptive and sustainable management are made.

## L’évaluation de la production de liège dans les nouvelles plantations de Quercus suber sous le futur climat

La croissance annuelle de liège est liée aux conditions climatiques, à savoir les précipitations enregistrées en automne et en hiver. La plupart des scénarios climatiques existants suggèrent une baisse des précipitations au Portugal, qui pourrait avoir un impact sur le taux de croissances des arbres, la production de liège et par conséquent les périodes de rotation de l’écorçage du liège appliquées dans la gestion forestière actuelle. Pour l’heure, aucun modèle fondé sur les processus existant n’inclut de module associé à la croissance et à la production de liège. Les équations pour prévoir la croissance et la production du liège ont été ajoutées au modèle Yield-SAFE pauvre en paramètres, récemment calibré pour le chêne liège au Portugal. Les équations pour prévoir la production de liège dépendent de la taille de l’arbre (diamètre), elle-même déterminée par la croissance de l’arbre, dépendante des variables climatiques. L’étude a été réalisée sur deux nouveaux peuplements, plantés après 1990, qui ont été installés avec des densités élevées. Cette caractéristique tend à créer des peuplements avec un nombre d’arbres plus élevé par hectare dans l’avenir, mais des incertitudes subsistent sur la production du liège qui en découlera, car celle-ci est liée à la lumière et à la disponibilité hydrique, l’eau étant la principale ressource de limitation pour la plupart des peuplements actuels de chêne-liège. Les simulations pour les 40 prochaines années ont été effectuées pour deux peuplements, situés respectivement dans l’intérieur des terres et à proximité de la ligne côtière. Tous deux ont été installés en 1992, affichent un espacement similaire entre les arbres, mais présentent des types de sols différents. Leur écorçage commence pour la première fois. Les projections pour comparer le climat actuel et futur sont effectuées pour permettre la compréhension de l’impact du changement climatique sur la croissance des arbres et la production de liège. Des suggestions pour une gestion adaptée et durables sont formulées.

# Are forest fungi affected by climate change? Diversity and structure of ectomycorrhizal fungal communities along altitudinal gradients in Europe

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The relationship between energy gradients and community richness and diversity has been well documented in community ecology for numerous groups of organisms. However, little information exists concerning the impact of these gradients on the ectomycorrhizal (EM) fungal communities, a key component of forests functioning. EM fungi form symbiosis with the roots of trees, aiding them to improve the uptake of water and nutrients from the soil. This study aimed to test how EM fungal diversity might be influenced by climate change by using altitudinal gradients as a proxy, while also taking into account potential host, weather and soil effects. We checked whether EM fungal communities associated with two representative European tree species: Fagus sylvatica L. and Pinus sylvestris L., were structured by climatic factors. Surveys for collecting EM root samples were performed along different altitudinal gradients in beech and pine forests located in France, Italy and Spain. Four gradients were studied as independent spatial repetitions across France/Italy (Vosges, Pyrenees, Alps and Appenines) in the case of beech, and three gradients across Spain/France (Guadarrama, Pyrenees and Vosges) in the case of pine. Total DNA was extracted from roots and the fungal ITS-1 region amplified by PCR using the primers ITS1F/ITS2 suitably tagged for high-throughput sequencing analyses (454 FLX pyrosequencing). Specific EM community composition of each tree species, diversity estimates, and correlations with environmental parameters will be presented to highlight the patterns of EM distribution along these gradients for both types of forests. First analyses revealed that soil pH was the most important environmental parameter structuring the EM fungal communities. On the other hand, EM fungal richness did not seem to be affected by temperature. Future perspectives to study these fungal communities along a European latitudinal gradient are additionally presented.

# Le changement climatique a-t-il une influence sur les champignons forestiers ? Diversité et structure des communautés fongiques ectomycorhiziennes sur des gradients altitudinaux en Europe

La relation entre les gradients énergétiques et la richesse et la diversité des communautés bénéficie d'une documentation fouillée pour de nombreux groupes et organismes. Néanmoins, rares sont les informations existantes sur l'impact de ces gradients sur les communautés fongiques ectomycorhiziennes (EM), un composant clé du fonctionnement des forêts. Les champignons EM entrent en symbiose avec les racines des arbres et les aident à améliorer l'absorption d'eau et de nutriments dans le sol. Cette étude a pour objectif de tester en quoi la diversité fongique EM peut subir l'influence du changement climatique en s'appuyant sur des gradient altitudinaux pour servir de données indirectes, tout en tenant également compte des effets potentiels liés à l'hôte, aux conditions météorologiques et au sol. Nous avons vérifié si les communautés fongiques EM associées avec deux essences d'arbres largement représentées en Europe, Fagus sylvatica L. et Pinus sylvestris L., sont structurées par les facteurs climatiques. La collecte des échantillons de racines EM s'est faite sur différents gradients altitudinaux de forêts de hêtre et de pin situées en France, en Italie et en Espagne. Quatre gradients ont été étudiés comme répétitions spatiales indépendantes en France et en Italie (Vosges, Pyrénées, Alpes et Apennins) pour le hêtre, et trois gradients en Espagne et en France (Guadarrama, Pyrénées et Vosges) pour le pin. L'ADN total a été extrait des racines et la région fongique ITS-1 amplifiée par PCR en utilisant les amorces ITS1F/ITS2 taguées pour des analyses de séquençage à rendement élevé (pyroséquençage 454 FLX). La composition spécifique de la communauté EM de chacune des essences d'arbres, une évaluation de la diversité et les corrélations avec les paramètres environnementaux seront présentées pour souligner les schémas de distribution EM sur ces gradients pour les deux types de forêts. Les premières analyses révèlent que le pH du sol est le paramètre environnemental structurant les communautés fongiques EM le plus important. La richesse fongique EM ne semble en outre pas affectée par la température. Des perspectives d'études sont ici présentées à titre complémentaire.

## Effect of altitude on forest herbivores and their parasitoids: a meta-analysis

Marc KENIS - CABI Europe-Switzerland, Delémont - Switzerland
Christelle PERE - CABI Europe-Switzerland, Delémont - Switzerland
Hervé JACTEL - INRA, UMR BIOGECO, Bordeaux – France

Climate change is known to affect the abundance and impact of forest pests on forest productivity and ecosystems. These effects may either be direct, i.e. effects on the biology of the pest itself, or indirect through effects on their host plants or their natural enemies. Two major issues in studying such effects are, firstly, the fact studies tend to focus on single species and, therefore, results are difficult to extrapolate to other species. Secondly, climate change is a slow process and, ideally, observations should to be done over a long period of time, which is rarely possible. In the EU-funded project BACCARA, we use various alternative approaches to assess the effect of climate change on forest pests and their natural enemies. In particular, we use the concept of functional groups and altitudinal gradients as analogues of global warming. Both field and literature studies are presently being carried out. At the conference, we will present the results of meta-analyses of published and unpublished data on variations of herbivore abundance and parasitism along altitudinal gradients, to derive common responses of forest herbivores and their parasitoids to altitude. Analyses are on-going, but first results show that parasitism significantly decrease with altitude, especially in temperate regions and in natural or semi-natural habitats. Implications for forest management in Europe will be discussed.

## Effets de l'altitude sur les herbivores forestiers et leurs parasitoïdes : méta-analyse

Le changement climatique a des conséquences sur l'abondance et l'impact des nuisibles sur la productivité et les écosystèmes forestiers. Ces effets peuvent être directs – sur la biologie des nuisibles – ou indirects – sur les plantes hôtes ou leurs ennemis naturels. L'étude de ces effets pose deux questions majeures : premièrement, les études ont tendance à se concentrer sur une seule espèce et, par conséquent, les résultats sont difficiles à extrapoler sur d'autres espèces. Deuxièmement, le changement climatique est un processus lent et, dans l'idéal, les observations devraient se faire sur une longue période, ce qui est rarement possible. Dans le projet BACCARA, financé par l'UE, nous nous appuyons sur des méthodes alternatives pour évaluer l'effet du changement climatique sur les nuisibles et leurs ennemis naturels. Plus particulièrement, nous utilisons le concept de groupes fonctionnels et de gradients altitudinaux en analogie du réchauffement climatique. Les études documentaires et terrain sont en cours. Nous présenterons lors de la conférence les résultats des méta-analyses des données publiées et non publiées sur les variations de l'abondance et du parasitisme des herbivores sur des gradients altitudinaux, afin de dériver des réponses communes aux herbivores forestiers et à leur parasitoïdes en altitude. Les analyses se poursuivent, mais les premiers résultats indiquent que le parasitisme décroît de manière significative avec l'altitude, particulièrement dans les régions tempérées et dans les habitats naturels ou semi-naturels. Les implications pour la gestion forestière seront également abordées.

# PRODUCTIVITY, DISTRIBUTION 2

**Tuesday 22 May**

**10:45 – 12:30. Scientific Parallel Sessions 3**

## Impact of climate on growth and mortality of trees in the Black Forest

Heinrich SPIECKER - Institute for Forest Growth - Germany

Intensive forest management in the Black Forest led to highly productive forests. Thirty years ago, forest owners and the public were severely concerned about the media reports on fatal forest decline in this region. In recent years tree mortality increased substantially, but it has been almost ignored by the public. This presentation analyses the relation between the periodic variation of tree growth, tree mortality and the climatic water balance during the last 50 years in the Black Forest.

# Impact du climat sur la croissance et la mortalité des arbres dans la Forêt Noire

La gestion forestière intensive dans la Forêt Noire a généré des forêts extrêmement productives. Il y a trente ans, les propriétaires forestiers et le public se sont sérieusement préoccupés de rapports médiatiques sur le déclin fatal des forêts de la région. Ces dernières années, la mortalité des arbres a augmenté de manière significative, un phénomène pratiquement ignoré par le public. Cette présentation analyse la relation entre la variation périodique de la croissance des arbres, la mortalité des arbres et l'équilibre des précipitations depuis cinquante ans dans la Forêt Noire.

# The impact of climate change on the health condition and yield of sessile oak along its xeric limit

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Dr. Imre BERKI - University of West Hungary, Faculty of Forestry, NEESPI Focus Research Center on Non-boreal Southeast Europe, Institute of Environmental and Earth Sciences - Hungary
Dr. Norbert MÓRICZ - University of West Hungary, Faculty of Forestry, NEESPI Focus Research Center on Non-boreal Southeast Europe, Institute of Environmental and Earth Sciences - Hungary
Ervin RASZTOVITS - University of West Hungary, Faculty of Forestry, NEESPI Focus Research Center on Non-boreal Southeast Europe, Institute of Environmental and Earth Sciences – Hungary

The effect of global warming and the elevated CO2 concentration on growth and health condition of different tree species has been investigated in numerous countries. In western and northern part of Europe, where water for evapotranspiration is available throughout the year, increasing temperature and CO2 concentration result in accelerated growth. During the last three decades, several serious drought periods occurred in Central and Southeast Europe. In the early of 80's, mass mortality of sessile and pedunculate oak appeared due to consecutive drought years. During the dry summers of the early 90's, Norway spruce was also heavily damaged. The unprecedented drought period between 2000 and 2003 has triggered a large-scale beech decline in the Carpathian Basin. Sessile oak was affected during all three drought periods. The vitality decline of oak stands, affected by climate extremes was determined by investigating the health status of remaining trees and the rate of mortality in the recent decades was also surveyed. Main characteristics (health status, stand density and volume) of selected stands have been evaluated. The data of investigated stands were compared with yield tables, compiled fifty years ago. The results indicate that effect of increasing CO2 and nitrogen concentration are partially compensating the effect of drier climate by increased growth increment.

## Impact du changement climatique sur l’état de santé et le rendement du chêne sessile sur sa lisière aride

L’effet du réchauffement climatique et de la hausse de la concentration en $CO_2$ sur la croissance et l’état de santé de différentes essences d’arbres fait l’objet d’études dans de nombreux pays. Dans l’ouest et le nord de l’Europe, où l’eau par évapotranspiration est disponible tout au long de l’année, la hausse des températures et de la concentration en $CO_2$ entraîne une accélération de la croissance. Au cours des trois dernières décades, l’Europe centrale et méridionale a connu plusieurs périodes de sécheresse aigue. Le début des années 1980 a vu une mortalité massive des chênes sessiles et pédonculés suite aux années de sécheresse. Pendant les étés secs du début des années 1990, l’épicéa de Norvège a lui aussi subi de lourds dégâts. La période de sécheresse sans précédent entre 2000 et 2003 a déclenché un déclin à grande échelle du hêtre dans le bassin des Carpates. Le chêne sessile a été touché pendant ces trois périodes de sécheresse. Le déclin de la vitalité des peuplements de chênes, touchés par les extrêmes climatiques, a été déterminé en étudiant l’état de santé des arbres restants. Le taux de mortalité des dernières décades a lui aussi été étudié. Les principales caractéristiques (état de santé, densité et volume) des peuplements sélectionnés ont été évaluées. Les données des peuplements étudiés ont été comparées avec les tableaux de rendement, dressés il y a cinquante ans. Les résultats indiquent que l’effet de la hausse de la concentration en $CO_2$ et en azote compense en partie les effets d’un climat plus aride par un accroissement plus élevé.

# Exploring Eucalyptus fastigata growth with 3PG projections in New Zealand under different climate scenarios

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PhD, João, PALMA - Forest Research Centre, School of Agronomy, Technical University of Lisbon – Portugal
MSc, Duncan, HARRISON - SCION - New Zealand
PhD, David, PALMER - SCION and Landcare Research - New Zealand

Eucalyptus fastigata is well suited for sequestering carbon in New Zealand. It is likely to be an integral component of the future establishment of carbon forests under New Zealand's Emissions Trading Scheme (ETS). However, existing empirical models for E. fastigata are unsuitable for predicting growth and yield due to a small number of research plots and a limited distribution. An alternative modelling approach is with process-based modelling. A preliminary calibration and validation of the process based model 3-PG was made and the project TRANZFOR (www.tranzfor.eu) enabled the endeavour to explore the yield over New Zealand in order to supply spatial information on where new plantations could occur and provide predictions on sequestration under present and future climates. Climate, soil water content and planting density were the three sources of variability. A 5km grid of current climate and three future climate scenarios (Canadian GCM) for New Zealand, three soil available water levels (100, 150 and 200 mm) and seven tree planting densities (800, 1000, 1200, 1400, 1600, 1800 and 2000 trees ha-1) were set up as inputs for 3-PG simulations to retrieve the stand volume at year 30. A total of 223,356 simulations were obtained for each climate scenario. Preliminary results of the spatial distribution with current climate conditions indicated that 3-PG provided a good prediction of stand volume trends for existing E. fastigata plantations. The results also supply information on productivity differences between climate scenarios and detect hotspots for targeting carbon sequestration needs.

## Exploration de la croissance de l'Eucalyptus fastigata par projections 3PG en Nouvelle-Zélande sous différents scénarios climatiques

Eucalyptus fastigata est bien adapté à la séquestration du carbone en Nouvelle-Zélande. Il est susceptible d'être un composant intégral de l'établissement futur de forêts carbonifères dans le cadre du système d'échange du quota d'émissions (ETS) du pays. Néanmoins, les modèles empiriques existants pour cette essence ne sont pas adaptés pour prévoir la croissance et le rendement en raison d'un nombre peu élevé de parcelles de recherche et d'une distribution limitée. Une méthode alternative s'appuie sur la modélisation fondée sur les processus. Une calibration et une validation préliminaires du modèle fondé sur les processus 3-PG ont été effectuées et le projet TRANZFOR (www.tranzfor.eu) a permis de tenter l'exploration du rendement en Nouvelle-Zélande afin de fournir des informations spatiales sur les emplacements possibles de nouvelles plantations et de formuler des prédictions sur la séquestration dans les climats actuels et futurs. Le climat, la teneur hydrique du sol et la densité de plantation ont servi de critères de variabilité. Une grille de 5 km du scénario climatique actuel et de trois scénarios (GCM canadien) pour la Nouvelle-Zélande, trois niveaux de teneur hydrique des sols disponibles (100, 150 et 200 mm) et sept densités de plantations (800, 1 000, 1 200, 1 400, 1 600, 1 800 et 2 000 arbres ha-1) ont servi pour les simulations 3-PG afin d'estimer le volume de peuplement pour l'année 30. En tout, 223 356 simulations ont été obtenues pour chaque scénario climatique. Les résultats préliminaires de la distribution spatiale dans les conditions climatiques actuelles indiquent que 3-PG a fourni une bonne prévision de la tendance des volumes de peuplements pour les plantations existantes de E. fastigata. Les résultats fournissent également des informations sur les différences de productivité entre les scénarios climatiques et détectent les zones sensibles pour cibler les besoins de séquestration carbone.

# Vulnerability of key French forest tree species to climate change, possibility of substitution of species in forestry

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Vincent BADEAU - INRA - France
Herve LE BOULER - conservatoire National Biodiversité Forestière , Ministère de l'agriculture – France
Brigitte MUSCH - Conservatoire Génétique des Arbres Forestiers, Unité sous contrat (ONF-INRA) – France
Myriam LEGAY - ONF , Département recherche , en charge de la vulnérabilité et de l'adaptation des forêts au changement climatique - France
Philippe RIOU-NIVERT - Institut pour le développement Forestier , CNPF – France

The French scientific studies on modeling of potential bioclimatic distribution areas of main forest species converge and underline significant future consequences. The results of these studies leaning on IPCC climatic models for the 21st century are convergent. In French plains and hills regions, apart from Mediterranean region, the set of broadleaf trees and conifer species, indigenous and exogenous which is one of the mainstays of timber will be impacted over the next few years. This impact essentially results in the increase of water deficit. Some drought-tolerant species (thermophilic pines, evergreen broadleaf trees) would see their potential area increase due to the improvement of limiting factors (winter cold, sum of temperatures in vegetation season). However, a large majority of species (deciduous Fagacea and locally introduced resinous; Abies, Picea, Pseudotsuga) would see a large part of their actual repartition and crop area significantly reduced since out of the conditions of their climatic niche. These species present the special feature of encountering in French plains their limits for water deficit resistance. The presentation will introduce a compared analysis of different available modeling. It will propose for the main productive species a regionalized synthesis at the scale of sylvo-eco-regions defined by the National Forest Inventory integrating silvicultural issue. This study realized within the AFORCE framework includes operational outcomes which will be introduced too: - Application of identified vulnerability to secure significant genetic resources via assisted migration. - Regionalized inventory of potential substitute species and provenances. - Simple protocol for installation of demonstrative site of substitute introduction species.

## Vulnérabilité au changement climatique des principales essences forestières françaises, possibilité de substitution

Les études scientifiques françaises sur la modélisation des zones bioclimatiques de distribution potentielle des principales essences convergent et mettent en avant les futures conséquences significatives. Leurs résultats, qui s'appuient sur les modèles climatiques du GIEC pour le XXIe siècle, convergent eux aussi. Dans les plaines et les collines françaises, à l'exception de la région méditerranéenne, le panel de feuillus et de résineux, indigènes et exogènes, qui constitue l'un des piliers du bois d'œuvre, sera impacté sur les prochaines années. Cet impact résulte essentiellement du déficit hydrique accru. Certaines essences tolérantes à la sécheresse (pins thermophiles, feuillus persistants) verraient leur aire potentielle augmenter avec le renforcement de facteurs contraignants (froid hivernal, somme des températures en saison de végétation). Néanmoins, une vaste majorité d'essences (Fagacées caducs et résineux introduits localement ; Abies, Picea, Pseudotsuga) verraient une grande part de leur distribution et de leur superficie réduite pour cause de resserrement de leur niche climatique. Ces essences présentent la caractéristique de rencontrer dans les plaines françaises leurs limites de résistance au déficit hydrique. La présentation introduira une analyse comparée des différentes modélisations disponibles. Elle proposera pour les principales essences productrices une synthèse régionale à l'échelle des régions éco-sylvicoles définies par l'IFN en intégrant la question de la sylviculture. Cette étude réalisée dans le cadre AFORCE inclut des résultats opérationnels qui seront présentés également : application de la vulnérabilité identifiée pour sécuriser les ressources génétiques significatives par migration assistée ; inventaire régionalisé des essences de substitution potentielles et de leur provenance ; protocole simple pour l'installation de sites de démonstration d'introduction d'essences de substitution.

# MANAGEMENT FOR ADAPTATION 1

**Tuesday 22 May**

**10:45 – 12:30. Scientific Parallel Sessions 3**

## The role of forestry in national climate change adaptation policy: An explorative assessment of cases from Sweden, Germany, France and Italy

Professor E. Carina H. KESKITALO - Umeå University, Sweden - Sweden
Myriam LEGAY - ONF - France
Marco MARCHETTI - Department STAT, University of Molise – Italy
Susanna NOCENTINI - Department of Agricultural and Forestry Economics, Engineering, Sciences and Technologies, University of Florence - Italy
Peter SPATHELF - Angewandter Waldbau, Fachbereich für Wald und Umwelt, Hochschule für Nachhaltige Entwicklung (HNE) Eberswalde – Germany

Forestry is one of Europe's largest land uses, for which adaptation to climate change will require coordinated action among multiple actors. However, so far, adaptation has been less placed in focus than has mitigation, and adaptation in the forest sector has mainly been reactive. This paper explores and reviews the integration of forestry in the development of planned adaptation policy in different countries, in particular suggesting some measures that may affect the inclusion of such a sector with a large number of diverging interests in adaptation. Sweden, Germany and France are taken as examples of countries with different development of their adaptation policies as well as different requirements of their forest systems and actors. Italy is utilised as an example of how adaptation actions for forestry have been defined in a country where no national adaptation policy as of yet exists. The study indicates that policy development on adaptation in forestry has in Sweden, Germany and France has been undertaken as part of the development of more general adaptation policy at national level, whereas it in Italy has been developed to a lower extent in documents targeting other policy areas. The different structure of the countries also result in certain differences in how approaches to adaptation are developed.

## Rôle de la sylviculture dans la politique nationale d'adaptation au changement climatique : analyse exploratoire des cas de la Suède, de l'Allemagne, de la France et de l'Italie

La sylviculture est l'une des utilisations des terres les plus répandues en Europe. Son adaptation au changement climatique requiert une action coordonnée auprès d'acteurs multiples. Pour l'heure, l'adaptation a toutefois bénéficié d'une attention inférieure à celle réservée à l'atténuation ; l'adaptation du secteur forestier reste principalement réactive. Cette présentation explore et analyse l'intégration de la sylviculture dans le développement d'une politique d'adaptation planifiée dans divers pays, en particulier en suggérant certaines mesures qui concernent l'inclusion d'un secteur présentant un grand nombre d'intérêts divergents. La Suède, l'Allemagne et la France servent d'exemples de pays proposant des développements différents de leur politique d'adaptation ainsi que des exigences différentes de leurs systèmes et acteurs forestiers. L'Italie sert à illustrer comment les actions d'adaptation pour la sylviculture ont été définies dans un pays où aucune politique nationale d'adaptation n'existe. Cette étude indique que le développement de politiques d'adaptation de la sylviculture en Suède, en Allemagne et en France s'inscrit dans le cadre du développement d'une politique d'adaptation plus générale à l'échelle nationale, tandis qu'en Italie, elle se développe dans une portée inférieure dans les documents ciblant d'autres domaines. Les structures différentes des pays entraînent également certaines différentes dans la façon dont les politiques d'adaptation sont développées.

# REsource INFrastructures for monitoring, adapting and protecting european atlantic FORests under Changing climate

Mr, Christophe, ORAZIO - EFIATLANTIC - France
Ms, Luisa, DI LUCCHIO - EFIATLANTIC - France

OBJECTIVES The main aim of the REINFFORCE project is to set up a network of trials to monitor disturbance in the life cycle of trees, introduction of new pathogens, misadaptation of trees to local conditions, caused by climate changes and to test adaptive measures efficiency. This network will mainly cover the European Atlantic area as it is founded by INTERREG-IVB Atlantic Area. MATERIALS AND METHODS A network of trials will be set up to monitor and evaluate both the adaptation capacity of different species of forest trees to new climatic conditions and the comparison between the classical and the adaptive management techniques. The network is located along the Atlantic rim and it is constituted by 38 arboreta and 32 (?) demonstration sites. The locations have been selected by the partners of the project on the base of specific soil and climatic conditions so that the same genetic material produced in the same conditions will be exposed to various climate/soil contexts. For the establishment of the arboreta 32 tree species have been identified during a species selection process based on outputs from a decision support tool, using 17 indicators to estimate the potential adaptation of the chosen species. A total of 2000 trees per arboreta will be planted, following the scheme: 3 provenances per species * 12 trees plus 4 'replicates' that will be planted three times, randomly, to assess site variability 450 site specific provenances In the demonstration sites various silvicultural techniques will be applied depending on the climatic addressed adaptation risks. For example, the wind risk for a Pine plantation will be faced improving the site preparation. Against the drought risk the soil organic matter will be enriched to improve soil water holding capacity using biochar. The adaptation management will be validate comparing it to the classical Silviculture. All the network establishment process is based on the report of the state of the art of regional climate change and forest actions. RESULTS A field manual for the site description , tree measurements , biotic and abiotic damage assessment , phenology and the protocol for site management has been drawn for the first 15 years after the installation. The data collected will constitute an internal data base that will be used by the partners and shared for the needed analysis. A register of forest long term monitoring trials made in Europe is already available for scientific purposes, any organisation can contribute.

## REINFFORCE (Infrastructures de ressources pour le contrôle, l'adaptation et la protection des forêts atlantiques européennes face au changement climatique)

OBJECTIFS - L'objectif principal du projet REINFFORCE est de mettre en place un réseau d'essais pour suivre les perturbations du cycle de vie des arbres, l'introduction de nouveaux pathogènes, l'inadéquation des arbres aux conditions locales en raison des changements climatiques, et éprouver l'efficacité des mesures adaptatives. Ce réseau couvre principalement l'aire atlantique européenne car il s'appuie sur l'INTERREG-IVB Espace Atlantique. MATERIELS ET MÉTHODES - Un réseau d'essais sera mis en place pour suivre et évaluer la capacité d'adaptation des différentes essences d'arbres forestiers aux nouvelles conditions climatiques et pour comparer les techniques de gestion traditionnelles et adaptatives. Le réseau s'étend le long de l'arc atlantique et se compose de 38 arboretums et 32 (?) sites de démonstration. Les sites ont été sélectionnés par les partenaires du projet sur la base des conditions de sol et de climat spécifiques : les mêmes supports génétiques produits dans les mêmes conditions seront exposés à différents contextes climat/sol. Pour la mise en place des arboretums, 32 essences d'arbres ont été identifiées lors d'un processus de sélection fondé sur les produits d'un outil d'aide à la prise de décision, qui s'appuie sur 17 indicateurs pour évaluer le potentiel d'adaptation des essences retenues. 2 000 arbres par arboretum seront plantés, en suivant le schéma suivant : 3 provenances par essence * 12 arbres et 4 « répétitions » plantées trois fois, de manière aléatoire, pour évaluer la variabilité au site de 450 provenances spécifiques. Dans les sites de démonstration, diverses techniques de sylviculture seront appliquées en fonction des risques d'adaptation climatiques retenus. Ainsi, les risques liés au vent pour les plantations de pins seront pris en compte en améliorant la préparation du site. Pour les risques de sécheresse, la matière organique des sols sera enrichie par du biocharbon pour améliorer leur capacité de rétention hydrique. La gestion de l'adaptation sera validée en la comparant à la sylviculture classique. Tout le processus d'établissement du réseau se fonde sur les données de pointe régionales en matière d'actions climatiques et forestières. RÉSULTATS - Un manuel terrain pour la description du site, l'évaluation des arbres, l'évaluation des dommages biotiques et abiotiques, la phénologie et le protocole de gestion des sites a été rédigé pour les 15 premières années après installation. Les données collectées constitueront une base de données interne qui sera utilisée par les partenaires et partagée pour les besoins de l'analyse. Un registre des essais de suivi des forêts à long terme en Europe est déjà disponible à des fins scientifiques, et n'importe quelle organisation peut y contribuer.

## Designing Adaptive and Sustainable Forests in Response to Climate Change: A case study in Northern Wales

Ms. Stefania PIZZIRANI - Forest Research - United Kingdom
Mr. Duncan RAY - Forest Research - United Kingdom
Dr. Bruce NICOLL - Forest Research - United Kingdom
Mr. Stephen BATHGATE - Forest Research - United Kingdom
Dr. John FONWEBAN - Forest Research - United Kingdom

Forests are dynamic ecosystems that possess a natural ability to respond to the stresses presented by their surrounding environment. However, the rate of change is accelerating for climatic variables, frequency of damaging weather events, and land use priorities. It is therefore critical for the forestry-based sector to better prepare for changing risks and uncertainty by designing more resilient forests. As part of the EU 7th Framework MOTIVE project, a case study based in north Wales, UK has begun to design and test an adaptive forest management methodology for two scenarios ('conservative' and 'forward thinking'), with each scenario under two climate change trajectories (medium and high emissions). The process is initialised by running growth models (specific to each tree species) for a ten year period and assessing which forest stands should be felled because they have either reached their maximum growth potential or a high wind risk status. All harvested material from fellings and thinnings (remaining stands are thinned where appropriate) are processed through log and biomass assortment models to determine product volumes and associated value. The site and climate details of each felled area are then run through a suitability model which determines which species are best for that location. A site is replanted with a species that is both suitable and adheres to the adaptation strategy. Once the forest design plan has been updated with the details of the replanted areas, the process is repeated for every decade until 2100. Each of the models used are updated with future climate datasets to ensure an accurate response to projected climatic change is achieved. In addition, at the end of each decade, the effects of management decisions are assessed by measuring the impacts on a selection of sustainability indicators including Gross Value Added, Employment, Recreation, Greenhouse Gas Emissions, Carbon stock, Growing stock and increments, Biodiversity, and Abiotic and Biotic risk. Initial results have highlighted the importance of being able to combine datasets and utilise several models in the same methodology in order to be able to adapt to a multitude of stresses ranging from wind risk to varying species suitability under a changing climate. Furthermore, this process has created a platform on which forest managers, policy makers and researchers have been able discuss key issues and findings.

## Conception de forêts adaptatives et durables en réponse au changement climatique : étude de cas dans le nord du Pays de Galles

Les forêts sont des écosystèmes dynamiques qui possèdent une capacité naturelle à faire face aux contraintes de leur environnement. Néanmoins, le taux de changement s’accélère en raison des variables climatiques, de la fréquence des événements météorologiques défavorables et des priorités d’utilisation des terrains. Il est par conséquent essentiel pour le secteur forestier de mieux se préparer à l’évolution des risques et aux incertitudes en concevant des forêts plus résistantes. Dans le cadre du projet MOTIVE, financé par le 7$^{ème}$ programme-cadre (FP7) de l’UE, une étude de cas basée dans le nord du Pays de Galles, au Royaume-Uni, a commencé pour concevoir et éprouver une méthodologie de gestion forestière adaptative pour deux scénarios (« conservateur » et « novateur »). Chaque scénario fait l’objet de deux trajectoires climatiques (émissions intermédiaires et élevées). Le processus démarre avec l’utilisation de modèles de croissance (spécifiques à chaque essence) pour une période de dix ans et qui évalue les peuplements à abattre soit parce qu’ils ont atteint leur plein potentiel de croissance ou qu’ils sont très exposés aux risques liés au vent. Tous les échantillons collectés lors des abattages et des éclaircies (les peuplements restants sont éclaircis le cas échéant) sont traités par des modèles d’assortiment de biomasse et de coupe afin de déterminer les volumes produits et la valeur associée. Les détails de la station et du climat de chaque zone coupée sont alors transmis à un modèle d’adéquation qui détermine les essences les plus appropriées au site. Un site est replanté avec les essences adaptées et conformes à la stratégie d’adaptation. Une fois le plan de conception des forêts mis à jour avec le détail des zones replantées, le processus est réitéré pour chaque décade jusqu’en 2100. Chacun des modèles utilisés est mis à jour avec les lots de données climatiques à venir afin de garantir une réponse précise au changement climatique projeté. En outre, à la fin de chaque décade, les effets des décisions en matière de gestion sont évalués en mesurant l’impact sur une sélection d’indicateurs de durabilité y compris Valeur ajoutée brute, emploi, loisirs, émissions de gaz à effet de serre, stock carbone, stock et augmentations de croissance. biodiversité, et risque biotique et abiotique. Les premiers résultats mettent en avant l’importance de pouvoir combiner les lots de données et d’utiliser plusieurs modèles de la même méthodologie afin d’être en mesure de s’adapter à une multitude de contraintes qui vont du risque lié au vent aux variations d’adéquation des essences face au changement climatique. Par ailleurs, la procédure a donné naissance à une plate-forme sur laquelle les gestionnaires forestiers, les décisionnaires et les chercheurs peuvent discuter des questions et découvertes clés.

## Deployment of alternative species in conifer plantation forests in New Zealand and the United Kingdom as a means of adaptation to climate change – a comparative case study and risk analysis.

Dr. W.L. (Bill) MASON - Forest Research - United Kingdom
Dr. Dean MEASON - SCION - New Zealand

Conifer plantation forests in New Zealand and the United Kingdom share certain similarities in that they are dominated by fast growing non-native species (Pinus radiata in New Zealand and Picea sitchensis in the UK) which have provided the raw material for the development of internationally competitive wood-using industries. However, analysis of the impacts of projected climate change has suggested that these forests may become increasingly vulnerable to abiotic and biotic stressors such as wind, drought and various pests and pathogens. Therefore forest policies in both countries seek to encourage the planting and utilisation of a wider range of species (e.g. Eucalyptus spp., Pseudotsuga menziesii, Sequoia sempervirens) as a means of diversifying the existing plantation forests and so increasing their resilience against climate change. We review the evidence basis for the species proposed for use in the diversification strategies in New Zealand and in the UK: the former has focussed on five species whose growth and productivity are reasonably well known whereas in the latter a wider portfolio of species is being trialled. In part, this reflects a desire to achieve a greater variety of stand structures within forests in the UK. One aspect that has seemingly been neglected in the discussion of appropriate levels of diversification in these plantation forests is the development of a formal risk analysis of various silvicultural options from shortening of rotations through application of alternative silvicultural systems to change of species. We will present the results from such an analysis which will indicate that the appropriateness of a particular silvicultural option will be influenced by site type, climatic region, and the location of a forest in relation to various markets, including the demand for recreation and other non-market ecosystem services.

## Déploiement d'essences alternatives dans les forêts plantées de conifères en Nouvelle-Zélande et au Royaume-Uni comme moyen d'adaptation au changement climatique – étude de cas comparée et analyse des risques.

Les forêts plantées de conifères en Nouvelle-Zélande et au Royaume-Uni partagent certaines similitudes : elles sont dominées par des essences non natives à croissance rapide (Pinus radiata en Nouvelle-Zélande et Picea sitchensis au Royaume-Uni), qui ont servi de matière première au développement de secteurs bois très compétitifs à l'échelle internationale. Néanmoins, l'analyse des impacts du changement climatique annoncé au Royaume-Uni suggère que ces forêts pourraient devenir toujours plus vulnérables aux contraintes biotiques et abiotiques comme le vent, la sécheresse, et divers nuisibles et pathogènes. Par conséquent, les politiques forestières de ces deux pays, cherchent à encourager la plantation et l'utilisation d'une gamme élargie d'essences (par ex. Eucalyptus spp., Pseudotsuga menziesii, Sequoia sempervirens) afin de diversifier les forêts plantées existantes et ainsi améliorer leur résistance au changement climatique. Nous analysons la base de connaissance pour les essences proposées pour les stratégies de diversification en Nouvelle-Zélande et au Royaume-Uni : la Nouvelle-Zélande se concentre sur cinq essences dont la croissance et la productivité sont raisonnablement bien connues tandis que le Royaume-Uni essaie un portefeuille élargi. Cette différence reflète en partie le désir d'obtenir une plus grande variété de structures de peuplements au sein des forêts britanniques. La discussion sur les niveaux appropriés de diversification de ces forêts plantées semble négliger un aspect : le développement d'une analyse formelle des risques des différentes options sylvicoles, depuis le raccourcissement des rotations par l'application de systèmes sylvicoles alternatifs au changement d'essences. Nous présentons les résultats de cette analyse qui indiquent que l'adéquation d'une option sylvicole particulière est influencée par le type de station, la région climatique, et la localisation de la forêt par rapport à différents marchés, y compris la demande en loisirs et les autres services écosystémiques non commerciaux.

# Adaptive management of mountain forests

Robert JANDL - BFW - Austria
Andreas SCHINDLBACHER - BFW – Austria

We present simulation experiments for Austrian mountain forests under two climate scenarios and two management scenarios. We elaborate whether the existing forests are likely to cope with a future climate, evaluate the required investments in forest management, and draw conclusions on the expected management intensity. Mountain forests provide several unreplaceable ecosystem services such 'protection against natural hazards' and 'carbon sequestration'. We will develop scenarios how these services can be provided, even when forest management is getting more expensive due to extended monitoring requirements (invading insects due to climate change) and at a decling workforce. Our conclusions are based on expert opinion and on a far reaching stakeholder involvement process. Simulation data will be used to visualize the framing conditions and to constrain the range of suggested solutions. The work is part of a larger exercise of compiling case studies for possible futures of mountain forests.

## Gestion adaptative des forêts de montagne

Nous présentons des simulations sur les forêts de montagne autrichiennes dans deux scénarios climatiques et deux scénarios de gestion différents. Nous étudions si les forêts existantes sont susceptibles de pouvoir faire face au changement climatique, nous évaluons les investissements nécessaires en matière de gestion forestière et nous dressons des conclusions sur l'intensité nécessaire de gestion. Les forêts de montagne fournissent plusieurs services écosystémiques irremplaçables de type « protection contre les risques naturels » et « séquestration carbone ». Nous allons développer des scénarios sur la manière dont ces services peuvent être fournis, même quand la gestion forestière devient plus onéreuse en raison des exigences accrues en matière de contrôle (invasions d'insectes en raison du changement climatique) et du déclin des effectifs. Nos conclusions se fondent sur l'opinion d'experts et un large processus d'implication des parties prenantes. Les données de simulation seront utilisées pour visualiser les conditions de cadrage et pour contraindre la gamme de solutions suggérées. Ce travail s'inscrit dans le cadre d'un exercice plus vaste de compilation d'études de cas sur l'avenir possible des forêts de montagne.

# Optimizing the management of even-aged beech stands under climate change uncertainty

Dr., Antoni, TRASOBARES - ETH Zurich - Switzerland
Prof. Dr., Bo Jellesmark., THORSEN - University of Copenhagen - Denmark
Dr, Jette Bredahl, JACOBSEN - University of Copenhagen – Denmark
Dr, Rasoul, YOUSEFPOUR - University of Copenhagen - Denmark
Prof. Dr., Harald, BUGMANN - ETH Zurich – Switzerland

We use the case of even-aged beech stands in Switzerland to illustrate the application of a new climate-sensitive growth-and-yield model for exploring the implications of climate change uncertainty. The model considers individual-tree diameter and height growth, including the self-thinning limit and the probability of a tree to survive any 5-yr period. Climate sensitivity is introduced through explicit climatic effects in the growth and survival functions. The model is combined with a search based optimization algorithm (e.g., Hooke and Jeeves) to find optimal management regimes according to a given initial state, objective function (e.g., net present value) and underlying climate scenario. The decision variables are (i) thinning times, expressed as years since stand establishment or previous thinning, and (ii) the remaining stand's basal area after each thinning. Furthermore, we analyze the sensitivity of management regimes to the degree to which the decision maker takes into account information about past, current and future climate variation and development. This approach allows us to span the documented variation in forest owners' awareness about climate change and their adaptive behaviour.

## Optimisation des peuplements équiens de hêtre dans le contexte des incertitudes liées au changement climatique

Nous nous appuyons sur le cas de peuplements équiens de hêtre en Suisse pour illustrer l'application d'un nouveau modèle de croissance et de rendement sensible au climat et explorer les implications des incertitudes liées au changement climatique. Ce modèle s'intéresse au diamètre individuel des arbres et à leur croissance en hauteur, y compris la limite d'auto-éclaircie et la probabilité de survie d'un arbre sur une période de cinq ans. La sensibilité au climat est introduite par le biais d'effets climatiques explicites sur les fonctions de croissance et de survie. Le modèle est associé à un algorithme d'optimisation fondé sur la recherche (par ex. Hooke and Jeeves) pour définir les régimes de gestion optimaux selon un état initial donné, une fonction objective (par ex. valeur actualisée nette) et le scénario climatique sous-jacent. Les variables de décision sont (i) les périodes d'éclaircie, exprimées en années depuis l'établissement du peuplement ou l'éclaircie précédente et (ii) l'aire de base du peuplement restant après chaque éclaircie. En outre, nous analysons la sensibilité des régimes de gestion au degré auquel le décisionnaire tient compte de l'information sur les variations et le développement climatiques passés, actuels et futurs. Cette méthode nous permet de couvrir la variation documentée de la sensibilisation des propriétaires forestiers au changement climatique et leur comportement adaptatif.

# MITIGATION 1

**Tuesday 22 May**

**10:45 – 12:30. Scientific Parallel Sessions 3**

# Kyoto forests in Middle Zavolgie of Russia: monitoring, validation and certification

Pr. Eldar KURBANOV - Marstu - Russia
Dr. Oleg VOROBYOV - Marstu - Russia
Sergey LEZNIN - Marstu – Russia
Alexander GUBAYEV - Marstu – Russia

According to the Kyoto protocol, Joint implementation project is a mechanism where one industrialized country can finance a greenhouse-gase reducing project in another country. The investors in the project can in return claim credits for the reduction of carbon emission and carbon sequestration. The purpose of this case study was to investigate the potential for carbon sequestration from such projects. The study covers afforestation with Scots pine on unforested land (burnt areas, cleared spaces, gaps, etc.) in the Polgovie region of Russia. Three scenarious were compared: 1) no afforestation (baseline scenario); 2) afforestation with pine, and carbon sequestration only considering above-ground tree biomass; 3) afforestation with pine, but carbon sequestration in all pools will be accounted for. On average carbon sequestration in the above-ground tree biomass could be around 80 t C ha-1 during 50 years of pine (Pinus sylvestris L.) plantation growth with 54 to C ha-1 in the equilibrium storage. Considerable amount of carbon will be bound in the lower layer of the pine forest stand (24 t C ha-1), which is usually underestimated in afforestation projects of joint implementation, and wood based products (35 t C ha-1). Allocation of the sequestered carbon in equilibrium storage has the following percentages: 46 % in pine stands, 21 % in the lower level, and 33 % in the wood based products. In order to extend the carbon sequestration, harvested wood should be used to manufacture long term use products. The results indicate good potential for such projects on the investigated territory in long term perspectives in compliance with international costs for sequestered carbon.

## Les forêts Kyoto dans la Zavolgie centrale en Russie : contrôle, validation et certification

Selon le protocole de Kyoto, un projet de mise en œuvre conjointe est un mécanisme dans lequel un pays industrialisé peut financer un projet de réduction des émissions de gaz à effet de serre dans un autre pays. Les investisseurs de ce projet peuvent en retour obtenir des crédits pour la réduction des émissions de carbone et la séquestration carbone. Cette étude de cas a cherché à étudier le potentiel de séquestration de carbone de ces projets. L'étude couvre le reboisement par le pin d'Écosse des terres non forestières (aires brûlées, espaces nettoyés, écarts, etc.) dans la région de la Polgovie en Russie. Trois scénarios ont fait l'objet d'une comparaison : 1) pas de reboisement (scénario de base) ; 2) reboisement avec pins, et séquestration de carbone ne tenant compte que de la biomasse de surface ; 3) reboisement avec pins, mais séquestration de carbone tenant compte de tous les bassins. En moyenne, la séquestration de carbone dans la biomasse de surface peut avoisiner 80 t C ha-1 pendant 50 ans de croissance d'une plantation de pin (Pinus sylvestris L.) avec 54 t C ha-1 dans le réservoir d'équilibre. Des volumes considérables de carbone sont retenus dans la couche inférieure du peuplement de pins (24 t C ha-1), qui est en général sous-estimée dans les projets de reboisement de mise en œuvre commune, et dans les produits bois (35 t C ha-1). L'attribution du carbone séquestré dans le réservoir d'équilibre affiche les pourcentages suivants : 46 % dans les peuplements de pin, 21 % dans la strate inférieure et 33 % dans les produits bois. Afin d'étendre la séquestration carbone, le bois récolté doit être utilisé pour la fabrication de produits à utilisation à long terme. Les résultats indiquent un bon potentiel de perspectives à long terme pour ces projets sur le territoire étudié, conformes aux coûts internationaux du carbone séquestré.

## Wood preservation (carbon sequestration) or wood burning (fossil-fuel substitution), which is best for mitigating climate change?

Pr Philippe LETURCQ - Toulouse University (INSA and LAAS-CNRS) - retired - France

The world's forests act as a carbon sink of approximately two billion tons of carbon per year (2 GtCy-1), balancing about 20% of the present anthropogenic carbon dioxide emissions. There is broad agreement upon the necessity of enlarging carbon sink efficiency by impeding deforestation, improving the management of existing forests and restoring forest cover wherever possible. However, the effective ways of using wood production with a view to mitigating climate change are still disputed. Currently there are two major opposing conceptions. One is based on the idea of increasing the carbon stock in living forest biomass, in wood products or in some kind of long-term wood storage, thus giving primacy to carbon sequestration. The other recommends the use of wood as a fuel, invoking the notion of the carbon neutrality of biomass to assert that the substitution of wood for fossil fuels avoids carbon emissions. This paper contributes to this debate by comparing carbon footprints of heat generation according to variable proportions of wood and fossil fuels for a given ligneous production and a given energy requirement. On condition that the wood not needed for energy can be preserved for a long time*, one can conclude that fossil fuels, with the exception of coal, are less carbon emissive than wood, even if the principle of biomass carbon neutrality is accepted without restriction. The physical reason is that the intrinsic carbon emission factor for wood has the highest value among all fuels in common use. The environmental advantages of substituting wood for fossil fuels are therefore questionable. Furthermore, the concept of carbon neutrality, which is invoked for justifying such substitution, is problematic as it presupposes the permanency of carbon stocks in forest ecosystems as well as in the pool of wood products. Thus, reference to this concept tends to hide the transitory opportunity of allowing forests a dynamic role in carbon sequestration as climatic threats mount. To mitigate climate change, it is therefore better to store wood than use it as a fuel. *Preserved for a long time refers to the preservation of wood from degradation in standing trees, in wood products, or possibly in burial storage, with sufficient durability to contribute significantly to climate change mitigation (decadal to centennial time-scale).

## Stockage du bois en forêt (séquestration carbone) ou chauffage au bois (substitution aux combustibles fossiles), quelle solution pour réduire le changement climatique ?

Les forêts de la planète servent de puits de carbone d'environ deux milliards de tonnes de carbone par an (2 GtCy-1), et compensent environ 20 % des émissions actuelles de dioxyde de carbone anthropogéniques. Il y a un large consensus sur la nécessité d'augmenter l'efficacité des puits de carbone en empêchant la déforestation, en améliorant la gestion des forêts existantes et en restaurant la couverture forestière dès que possible. Néanmoins, les moyens efficaces d'utilisation de la production de bois pour réduire le changement climatique font toujours débat. À l'heure actuelle, deux conceptions s'opposent. L'une se fonde sur l'augmentation du stock de carbone dans la biomasse des forêts vivantes, dans les produits bois ou dans toute autre sorte de stockage du bois, donnant ainsi la priorité à la séquestration carbone. L'autre recommande l'utilisation du bois comme combustible, invoquant la notion de neutralité carbone de la biomasse qui postule que la substitution des combustibles fossiles par le bois évite des émissions de carbone. Cette présentation alimente le débat en comparant l'empreinte carbone de la génération de chaleur en fonction de proportions variables de bois et de combustibles fossiles pour une production ligneuse donnée et une demande énergétique définie. Sous réserve que le bois non nécessaire à l'énergie puisse être préservé sur le long terme(*), on peut conclure que les combustibles fossiles, à l'exception du charbon, sont moins émetteurs de carbone que le bois, même si le principe de neutralité carbone de la biomasse est accepté sans restriction. La raison physique est que le facteur d'émission carbone intrinsèque pour le bois a la valeur la plus élevée parmi tous les combustibles courants. Les avantages environnementaux de la substitution des combustibles fossiles par le bois peuvent par conséquent être remis en question. En outre, le concept de neutralité carbone, invoqué pour justifier cette substitution, est problématique car il présuppose la permanence des stocks de carbone dans les écosystèmes forestiers ainsi que dans le groupe de produits bois. La référence à ce concept tend par conséquent à masquer l'opportunité transitoire de permettre aux forêts de jouer un rôle dynamique dans la séquestration carbone alors que la menace climatique s'amplifie. Pour réduire le changement climatique, il vaut mieux par conséquent stocker le bois plutôt que l'utiliser comme combustible.

(*)Préservé sur le long terme de la dégradation dans les arbres existants, dans les produits bois ou même dans les réservoirs d'enfouissement, avec une durabilité suffisante pour contribuer de manière significative à l'atténuation du changement climatique (échelle décade et siècle).

# Dividing GHG emissions by 4 in the French housing sector: contribution of land use efficiency in forestry and agriculture

Arthur RIEDACKER - INRA and DSP - France
Stefano MIGLIORE - DSP - France

To stabilize the climate it is necessary, up to 2050, to divide present GHG emissions by 2 at the global level and by 4 in industrilalized countries like France.Wood, natural gas and nuclear electricity can help to reduce GHG emissions. But this target can only be achieved by relying first on wood and then on nuclear energy. Decision making to achieve this target need to rely on a global "Spatio-temporal and inter-sectoral approach for sustainable development" (STIFsd) which will be presented briefly. Integrated life cycle analysis (ILCA) are to be considered to assess impact of biomass utilization whereas for fossil fuel conventional life cycle are sufficient. It has been shown that to reach the above mentinned target it is necessary to rely primarely on wood and nuclear energy. Some additionnal plantation for biomass production may be necessary if nuclear energy contibution is not to be reduced. But if the contribution of the latter is to be reduced, yields of forest and non forest biomass are to be increased as well as the land use efficiency of agricultural crop production. This shows that for sustainable - not to be confused with sustainable forest management, the contibution of forest is to be considered within the framework of the whole land use and not in isolation.

# Diviser par 4 les émissions de gaz à effet de serre en France : contribution de l’efficacité de l’utilisation des terrains dans la sylviculture et l’agriculture

Pour stabiliser le climat, il est nécessaire d’ici à 2050, de diviser les émissions de gaz à effet de serre actuelles par 2 à l’échelle mondiale et par 4 dans les pays industrialisés comme la France. Le bois, le gaz naturel et l’énergie nucléaire peuvent contribuer à la réduction des émissions de gaz à effet de serre. Mais cet objectif ne peut être atteint qu’en s’appuyant d’abord sur le bois puis sur l’énergie nucléaire. La prise de décision doit s’appuyer sur une « Méthode spatiotemporelle et intersectorielle pour le développement durable » globale qui sera présentée succinctement. L’analyse intégrée du cycle de vie doit être prise en compte pour évaluer l’impact de l’utilisation de la biomasse, alors que pour les combustibles fossiles, le cycle de vie traditionnel est suffisant. Pour atteindre l’objectif mentionné, il est nécessaire de s’appuyer premièrement sur le bois et l’énergie nucléaire. Des plantations complémentaires pour la production de biomasse peuvent être nécessaires si la contribution de l’énergie nucléaire est maintenue en l’état. Mais dans le cas d’une réduction de cette dernière, le rendement de la biomasse forestière et non forestière doit augmenter ainsi que l’efficacité d’utilisation des terres de la production agricole. Cela montre que, pour être durable – à ne pas confondre avec une gestion forestière durable – la contribution des forêts doit être considérée dans le cadre de l’utilisation des terres dans leur ensemble et non pas isolément.

# Mitigation of climate change thru boreal forest management

Associate professor Kenneth SAHLÉN - SLU - Sweden
Dr Hans WINSA - Sveaskog – Sweden

In Sweden, 55 % or 22,5 million hectares of the land area, are covered by managed forests. During the period 1926-2000, the amount of sequestered carbon dioxide, stored in the trees and in the soil in Swedish conifer forests, have increased from 5600 to 7600 million tons. During the same period, 4300 million cubic meters of wood raw material have been harvested, corresponding to 3300 million tons of $CO_2$. In average, 70 million tons of carbon dioxide have been annually sequestered in the forests, which is more than the total carbon dioxide release in Sweden 2005. During a forest rotation, a period of net release of $CO_2$ occurs after clear cut. Establishment of a new $CO_2$ sequestering tree stand, results in a net $CO_2$ uptake, reaching its peak value at a tree age of 40-60 years. Tree $CO_2$ sequestration and growth will increase with increasing total tree needle area. Needle area may be increased thru tree management, by increasing the number of trees per hectare and/or supply of nitrogen fertilizer, facilitating a higher needle production per tree. Tree growth increases of 300% have been achieved in experiments with pine and spruce. If growth optimizing forest management is applied in practical scale, it is estimated that it is possible to increase the total growth by 50% in average during a rotation period. The total amount of sequestered $CO_2$ in the trees during 300 years is estimated to 1600 ton/hectare if traditional management is applied. Growth optimized management will result in sequestration of 2200 ton $CO_2$/hectare, whereas a forest left unmanaged would sequester 1000 tons of $CO_2$/hectare. Consequently, climate change is most efficiently mitigated by boreal conifer forests, if the main management objective is to achieve a high average tree growth per hectare. The tree biomass should be harvested at optimal times and used for substitution of fossil based raw material for e.g. energy production or construction purposes as houses and bridges.

## Réduction du changement climatique par la gestion des forêts boréales

En Suède, 55 % du pays – ou 22,5 millions d'hectares – sont couverts par les forêts gérées. Au cours de la période 1926-2000, le volume de dioxyde de carbone séquestré, stocké dans les arbres et le sol des forêts de conifères suédoises, a augmenté de 5 600 à 7 600 millions de tonnes. Au cours de la même période, 4 300 millions de mètres cube de bois ont été récoltés, soit 3 300 millions de tonnes de $CO_2$. En moyenne, 70 millions de tonnes de dioxyde de carbone sont séquestrées chaque année dans les forêts, soit plus que les émissions de dioxyde de carbone totales en Suède depuis 2005. Au cours d'une rotation forestière, une période d'émission nette de $CO_2$ survient après une récolte. L'établissement d'un nouveau peuplement séquestreur de $CO_2$, entraîne une absorption nette de $CO_2$ qui atteint son apogée quand les arbres sont âgés entre 40 et 60 ans. La séquestration de $CO_2$ des arbres et leur croissance augmenteront avec l'augmentation de la superficie totale des aiguilles. Celle-ci, peut être améliorée par la gestion forestière, en augmentant le nombre d'arbres par hectare et/ou l'apport de fertilisant azote, facilitant ainsi une plus grande production d'aiguilles par arbre. Une augmentation de la croissance des arbres de 300 % a déjà été obtenue dans des expérimentations sur les pins et les épicéas. Si une gestion forestière optimisée de la croissance est appliquée sur le terrain, il est possible d'augmenter la croissance totale de 50 % en moyenne au cours d'une période de rotation. Le volume total de $CO_2$ séquestré par les arbres en 300 ans s'élèverait à 1 600 tonnes/hectare en cas de gestion traditionnelle. Une gestion optimisée de la croissance permettrait une séquestration de 2 200 tonnes de $CO_2$/hectare, alors qu'une forêt non gérée ne séquestrerait que 1 000 tonnes de $CO_2$/hectare. Par conséquent, le changement climatique est atténué de manière plus efficace par les forêts de conifères boréales si l'objectif principal de gestion est d'atteindre un degré élevé de croissance moyenne par hectare. La biomasse doit être récoltée à des moments optimaux et utilisée pour substitution aux matériaux fossiles, par ex. pour la production énergétique ou la construction comme les maisons et les ponts.

## Assessing and improving the overall carbon balance of the forest-wood sector – methods and approaches, uncertainties and consequences

Dipl.-Ing.Silv. Sebastian, RUETER - Johann Heinrich von Thuenen-Institute (vTI) - Germany

Since the Bali Conference at the end of 2007, countries negotiate for an international post-2012 UNFCCC climate framework. Stopping deforestation and strengthening the carbon sequestration function of trees is still being seen as one important means to combat the rising concentration of CO2 in the atmosphere. This is inter alia reflected by proposals for more comprehensive and effective accounting rules in the LULUCF sector (Land use, land-use change and forestry) in the course of the latest rounds of the climate negotiations (UNFCCC 2009, UNFCCC 2010). Amongst others, a common proposal for the inclusion of harvested wood products (HWP) as an additional carbon pool could be agreed upon so far by the majority of countries. But also European and national policies incentivize the use of the renewable resource. Wood products provide important services to society e.g. in form of building material or as source for bioenergy. In order to quantify the 'real' carbon effects, identify the mitigation potential of the entire forest-wood sector, and thereby enable society and policy makers to create the right incentives for optimizing the sectors' carbon benefits, it is thus important to include all effects of timber usage: - Net-effect of carbon sequestration and harvest, measured as forest carbon stock-changes (covered in 1st commitment period (CP) of the Kyoto-Protocol) - Net-effect of delaying biogenic carbon emissions by the material use of HWP (not covered in 1st CP) - Substitution effects through the use of HWP as material or energy carrier (decrease of fossil GHG-emissions in the energy and industrial sectors, only indirectly covered so far) By the example of Germany, the presentation shows implications of different forest management scenarios (increase and decrease of harvest) on the overall carbon balance of the forestry-wood sector and its impact on those different carbon effects. It will address the implications of various calculation methodologies to be used, including its uncertainties and possible conclusions that can be drawn from that. Furthermore, the presentation highlights the differences between 'real' effects of timber usage on the atmospheric GHG concentration and the carbon balances that have been calculated on the basis of 'old' and the latest agreed accounting rules. This also includes an update on the outcomes of the LULUCF negotiations at COP 17 in Durban, December 2011. UNFCCC (2009) Draft decision -/CMP.5 Land use, land-use change and forestry. FCCC/KP/AWG/2009/17. UNFCCC (2010) Land use, land-use change and forestry. Addendum, Revised proposal by the Chair, FCCC/KP/AWG/2010/18/Add.1.

## Évaluer et améliorer le bilan carbone global du secteur forestier – méthodes et approches, incertitudes et conséquences.

Depuis la conférence de Bali de la fin 2007, les pays négocient un cadre climatique international CNUCC post-2012. Arrêter la déforestation et renforcer la fonction de séquestration carbone des arbres sont toujours considérés comme un moyen important de lutter contre la hausse de la concentration de $CO_2$ dans l'atmosphère. Cette notion se reflète dans les propositions pour des règles de calcul plus efficaces et exhaustives dans le secteur LULUCF (Land use, land-use change and forestry) au cours des derniers tours des négociations sur le climat (CNUCC 2009, CNUCC 2010). Entre autres, une proposition commune pour l'inclusion des produits bois comme groupe carbone complémentaire pourrait être décidée par une majorité des pays. Les politiques européennes et nationales favorisent également l'utilisation des ressources renouvelables. Les produits bois fournissent à la société des services importants, sous forme par exemple de matériau de construction ou de source de bioénergie. Afin de quantifier les effets carbone « réels », d'identifier le potentiel de réduction du secteur forestier dans son ensemble et par conséquent permettre à la société et aux décisionnaires de créer les bons facteurs de stimulation pour optimiser les bénéfices carbone du secteur, il est important d'inclure tous les effets de l'utilisation du bois d'œuvre :
- effet net de la séquestration carbone et de la récolte, mesuré en changements de stock carbone (couvert dans la première période d'engagement du protocole de Kyoto) – effet net du retardement des émissions carbone biogéniques par l'utilisation concrète du bois récolté (non couvert par le premier engagement) – effet de substitution par le biais de l'utilisation du bois de récolte comme matériau ou combustible (baisse des émissions de gaz à effet de serre fossiles dans les secteurs de l'énergie et de l'industrie, couverts seulement de manière indirecte pour l'instant). En prenant l'exemple de l'Allemagne, la présentation montre les implications des différents scénarios de gestion forestière (augmentation et réduction de la récolte) sur l'équilibre carbone global du secteur forestier et ses impacts sur ces différents effets carbone. Elle aborde les implications des diverses méthodes de calcul utilisées, et intègre les incertitudes et les conclusions possibles qui peuvent être dressées. En outre, la présentation souligne les différences entre les effets « réels » de l'utilisation du bois d'œuvre sur la concentration atmosphérique des gaz à effet de serre et les équilibres carbone calculés sur la base des « anciennes » règles de calcul et des dernières décidées. Elle inclut également une mise à jour sur les conclusions des négociations LULUCF du COP 17 à Durban, en décembre 2011. CNUCC (2009) Décision provisoire -/CMP.5 Land use, land-use change and forestry. FCCC/KP/AWG/2009/17. CNUCC (2010) Land use, land-use change and forestry. Annexe, Proposition révisée par la Présidence, FCCC/KP/AWG/2010/18/Add.1.

# DISTURBANCES 1

**Tuesday 22 May**

**14:00 – 15:45. Scientific Parallel Sessions 4**

# The WINDA-GALES wind damage probability planning tool

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The WINDA-GALES model is an integrated system of models for assessing the probability of wind damage to forest stands. It provides a geographically explicit environment for stand-wise calculation of the probability of exceeding critical windspeeds for wind damage in a landscape. The calculations are sensitive to the stability of the forest as well as to the local wind climate. The model can be used to evaluate silviculture strategies and forest planning options with respect to the probability of wind damage. The model uses a spatially explicit description of the forest landscape based on the WINDA model (Blennow & Sallnäs 2004; Blennow & Olofsson 2008) in which the GALES model (Gardiner et al. 2000) has been implemented. In WINDA-GALES, the GALES sub-model is used to estimate the stability of the forest stand in terms of critical wind speeds for uprooting and stem breakage at the stand edge or inside the stand. Spatial variables used as input to GALES are estimated using a geographical information system. Calculated critical wind speeds are linked to the geostrophic wind by taking into account effects of the terrain surrounding the stand using a rationale developed for the WAsP airflow model (Kristensen et al., 2000). Extreme value theory is used for calculating the probability of exceeding the critical windspeeds. The model can be used to evaluate silviculture strategies and forest planning options with respect to the probability of wind damage and to assess the potential probability of wind damage under a changed climate. In the latter case climate scenario data and a description of the state of the forest under climate change is used. The WINDA-GALES model has extended functionality compared to the WINDA (Blennow and Sallnäs 2004; Blennow & Olofsson 2008) and GALES (Gardiner et al 2000) models, on which it is based.

Blennow, K., Sallnäs, O., 2004. WINDA – A system of models for assessing the probability of wind damage to forest stands within a landscape. Ecological Modelling 175, 87-99.
Blennow, K., Olofsson, E., 2008. The probability of wind damage under a changed wind climate. Climatic Change 87, 347-360.
Gardiner, B., Peltola, H., Kellomäki, S., 2000. Comparison of two models for predicting the critical wind speeds required to damage coniferous trees. Ecological Modelling 129, 1–23.
Kristensen, L., Rathmann, O., Hansen, S.O., 2000. Extreme winds in Denmark. J. Wind Eng. Ind. Aerodyn. 87, 147–166.

## WINDA-GALES, outil de planification de la probabilité des dommages dus au vent

WINDA-GALES est un système intégré de modèles destiné à évaluer la probabilité des dommages dus au vent dans les peuplements forestiers. Il fournit un environnement explicite sur le plan géographique pour le calcul à l'échelle du peuplement de la probabilité d'excès des vitesses éoliennes extrêmes pour les dommages dus au vent sur un paysage. Les calculs sont sensibles à la stabilité de la forêt ainsi qu'au climat venteux local. Le modèle peut être utilisé pour évaluer les stratégies de sylviculture et les options de planification forestière en matière de probabilité des dommages dus au vent. Il s'appuie sur une description explicite spatialement du paysage forestier fondée sur le modèle WINDA (Blennow & Sallnäs 2004 ; Blennow & Olofsson 2008) dans lequel le modèle GALES (Gardiner et al. 2000) a été mis en œuvre. Dans WINDA-GALES, le sous-modèle GALES est utilisé pour évaluer la stabilité du peuplement forestier en termes de vitesses éoliennes critiques pour le déracinement et le bris de branches à la lisière du peuplement et à l'intérieur. Les variables spatiales utilisées pour alimenter GALES sont évaluées en fonction d'un système d'information géographique. Les vitesses éoliennes critiques calculées sont associées au vent géostrophique en tenant compte des effets sur le terrain environnant le peuplement en utilisant une justification développée pour le modèle de flux d'air WAsP (Kristensen et al., 2000). La théorie des valeurs extrêmes est utilisée pour calculer la probabilité d'excéder les vitesses éoliennes extrêmes. Le modèle peut être utilisé pour évaluer les stratégies de sylviculture et les options de planification forestière à l'aune de la probabilité de dommages dus au vent et pour évaluer cette probabilité dans le contexte du changement climatique. Pour ce dernier cas, les données de scénario climatique et une description de l'état des forêts dans le contexte du changement climatique sont utilisées. Le modèle WINDA-GALES étend les fonctionnalités des modèles WINDA (Blennow and Sallnäs 2004 ; Blennow & Olofsson 2008) et GALES (Gardiner et al 2000), sur lesquels il s'appuie.

## Drivers and impacts of intensified disturbance regimes in European forests

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Dr. Mart-JAN SCHELHAAS - Alterra, Wageningen University and Research Centre, Wageningen – Netherlands

Natural disturbances from wildfire, strong wind, and insect outbreak are critical drivers of composition, structure and functioning of forest ecosystems. They also have a profound impact on ecosystem services such as the production of timber and the carbon exchange with the atmosphere. Observations across Europe show that forest disturbance regimes have intensified markedly in recent decades, resulting in a strong increase in damage from wind, bark beetles and wildfires. This intensification is increasingly challenging the continuous and sustainable provision of ecosystem services to society, particularly since climate change is expected to further fan disturbance regimes. Yet, our knowledge as to how past management and ongoing climate change are contributing to disturbance changes is still limited, and an improved understanding of their causes and impacts is needed in order to adapt management and policy to such changing disturbance regimes. Here, our aims were to unravel the drivers of the recently observed disturbance increase at European scale, and to estimate future disturbance levels and their impacts on timber production and carbon storage in Europe. Based on a comprehensive database documenting European disturbances we used an innovative fusion of statistical methods and continental scale scenario analyses by means of simulation modeling to (i) determine influential drivers of disturbance changes in the past, (ii) assess their trajectories in the mid-term future (2030), and (iii) estimate their impact in terms of forest C storage and timber volume damaged. We show that from 1958 to 2001, management-related changes in forest structure, composition, and extent contributed in the same order of magnitude as climate change to the increase in disturbance damage in Europe. Climate change was the main driver of the increase in area burnt, while changes in the forest vegetation particularly influenced variation in wind and bark beetle damage. Our projections suggest that disturbances will continue to increase in the mid-term future in many areas of Europe, with profound impacts on forest resources and the ecosystem C balance. It is thus of increasing importance to foster disturbance management capacities in forestry and develop strategies towards forest landscapes resilient to changing climate and disturbance regimes.

## Facteurs et impacts des régimes de perturbation intensifiés des forêts européennes

Les perturbations naturelles liées aux incendies, aux vents violents et aux invasions d'insectes sont des facteurs essentiels de composition, de structure et de fonctionnement des écosystèmes forestiers. Elles ont également un impact en profondeur sur les services écosystémiques comme la production de bois d'œuvre et les échanges de carbone avec l'atmosphère. Les observations en Europe indiquent que les régimes de perturbation des forêts se sont intensifiés de manière notoire dans les dernières décades, entraînant une forte augmentation des dommages dus aux vents, aux scolytes et aux incendies. Cette intensification remet toujours plus en question le caractère durable et permanent des services écosystémiques à la société, particulièrement depuis que le changement climatique est tenu pour facteur d'intensification de ces perturbations. Notre connaissance de la manière dont la gestion passée et le changement climatique en cours contribuent à la modification de ces perturbations reste restreinte, et une meilleure compréhension de leurs causes et de leurs impacts est nécessaire afin d'adapter la gestion et la politique forestière. Notre objectif est de dévoiler les facteurs d'augmentation récente de ces perturbations à l'échelle européenne, et d'évaluer les niveaux de perturbation futurs et leurs impacts sur la production de bois d'œuvre et le stockage carbone en Europe. En nous appuyant sur une large base de données exhaustive sur les perturbations européennes, nous avons utilisé une fusion innovante des méthodes statistiques et une analyse des scénarios à l'échelle continentale par le biais d'une modélisation de simulations pour (i) déterminer les facteurs d'influence des changements de perturbations par le passé, (ii) évaluer leurs trajectoires à moyen terme (2030), et (iii) évaluer leur impact en termes de stockage carbone des forêts et de volume de bois d'œuvre endommagé. Nous montrons que, de 1958 à 2001, les changements liés à la gestion de la structure des forêts, de leur composition et de leur extension ont contribué dans le même ordre d'amplitude que le changement climatique à augmenter les dommages liés aux perturbations en Europe. Le changement climatique a été le principal facteur d'augmentation de superficie dévastée par le feu, tandis que les changements de végétation forestière ont particulièrement influencé les variations des dommages causés par le vent et les scolytes. Nos projections suggèrent que les perturbations vont continuer d'augmenter à moyen terme dans de nombreuses régions européennes, avec des conséquences en profondeur sur les ressources forestières et l'équilibre carbone des écosystèmes. Il est par conséquent toujours plus important de renforcer les capacités de gestion des perturbations de la sylviculture et de développer des stratégies pour une résistance des paysages forestiers au changement climatique et aux régimes de perturbations.

# Observed and expected impact of climate change on a defoliator insect species, the pine processionary moth, in France and Europe

Christelle ROBINET - INRA - France
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The pine processionary moth (PPM), Thaumetopoea pityocampa, is one of the most severe pests of pine forests in France and Europe. This insect species causes some economic problems due to lower wood production, some human health problems due to urticating properties of the larvae, and aesthetic problems due to large white silk nests constructed by these gregarious larvae in the pine trees. Besides, this forest pest has recently become an urban pest, colonizing ornamental conifers. The geographic distribution of this Mediterranean species was relatively stable. However, since the early 1990s, the PPM has continuously extended its range by around 5.5 km/year toward Paris. The role of climate warming was clearly proved: increased winter temperatures enhanced the feeding activity of the PPM larvae and the survival rate of the colonies. Today, a large part of France and Europe is potentially favourable for the species establishment but this suitable area is not entirely colonized, partly due to limited dispersal capabilities of adults. This is a reason why human mediated dispersal can create satellite colonies and accelerate the PPM expansion within this suitable area. Therefore, the PPM cannot be considered as a true bioclimatic indicator of climate change. To record this range expansion at large scale and better understand better the role of the landscape, we determined the north edge of the PPM distribution in 2005-2006 and 2010-2011 over an 8 km x 8 km grid from western to eastern France based on a standardized method. We used the same method to determine the north edge limit over a 16 km x 16 km grid covering Europe (over France, Switzerland, Italy, Croatia, Bosnia & Herzegovina, Serbia & Montenegro, Albania, Macedonia, Bulgaria, and occidental Turkey). This mapping effort is essential to define a baseline for future studies. Although the northward edge of the PPM distribution is shifting northwards and the upper edge moving toward higher elevations, the effect on the southern edge in North Africa is still unknown. The effects of other factors are unknown too. For instance, after the heat-wave of the summer 2003, contradictory effects were observed: (1) a rapid expansion in higher elevations was observed in the Italian Alps, whereas (2) the population collapse was recorded in many regions of France, especially in the Paris Basin. Now it seems crucial to differentiate the effects of climate warming in average from the effects of weather conditions with fluctuations of higher magnitude. Estimating the future damage in forests is a challenge because of all these uncertainties and also because of the potential adaptation of this insect species.

## Impact observé et attendu du changement climatique sur une espèce d’insectes défoliateurs, la chenille processionnaire du pin, en France et en Europe

La chenille processionnaire du pin (CPP), Thaumetopoea pityocampa, est l’un des ravageurs les plus dangereux pour les pinèdes françaises et européennes. Cette espèce provoque des problèmes économiques en raison de son impact sur la production de bois, des problèmes sanitaires en raison des caractéristiques urticantes de la larve et des problèmes esthétiques en raison de grands nids de soie blanche construits par ces larves grégaires dans les pins. En outre, ce ravageur forestier est récemment devenu un nuisible urbain et colonise les conifères ornementaux. La distribution géographique de cette espèce méditerranéenne est longtemps restée relativement stable. Néanmoins, depuis le début des années 1990, elle accroît chaque année son étendue d’environ 5,5 km en direction de Paris. Le rôle du réchauffement climatique est clairement avéré : les températures hivernales en hausse ont renforcé les activités d’alimentation de la larve et le taux de survie des colonies. À l’heure actuelle, une grande partie de la France et de l’Europe constitue un environnement potentiellement favorable à l’établissement de l’espèce mais cette région adaptée n’est pas encore complètement colonisée, en partie en raison des capacités de dispersion limitées des adultes. Une dispersion facilitée par l’homme peut en revanche donner naissance à des colonies satellites et accélérer l’extension de la CPP dans les régions adéquates. Par conséquent, la chenille ne peut pas être considérée comme un indicateur bioclimatique fiable du changement climatique. Pour référencer cette expansion d’étendue à grande échelle et mieux comprendre le rôle du paysage, nous avons déterminé la lisière Nord de la distribution de la CPP en 2005-2006 et 2010-2011 sur une grille de 8 km x 8 km de l’ouest à l’est de la France sur la base d’une méthode standardisée. Nous avons appliqué la même méthode pour déterminer la lisière Nord sur une grille de 16 km x 16 km couvrant l’Europe (la France, la Suisse, l’Italie, la Croatie, la Bosnie-Herzégovine, la Serbie & le Monténégro, l’Albanie, la Macédoine, la Bulgarie, et la Turquie occidentale). Cette tentative de cartographie est essentielle pour définir un périmètre de référence pour nos prochaines études. Bien que la lisière Nord s’étende vers le Nord et que la lisière supérieure migre vers des altitudes plus élevées, l’effet sur la lisière Sud en Afrique du Nord reste inconnu. Les effets des autres facteurs sont eux aussi inconnus. Par exemple, après la vague de chaleur de l’été 2003, des effets contradictoires ont été observés : (1) une expansion rapide vers des altitudes plus élevées a été observée dans les Alpes italiennes, tandis qu’ (2) un effondrement de population a été observé dans de nombreuses régions françaises, particulièrement dans le bassin parisien. Il semble aujourd’hui essentiel de différencier les effets du réchauffement climatique de ceux des conditions météorologiques, avec des fluctuations d’amplitude plus élevée. Évaluer les futurs dommages dans les forêts est un réel défi en raison de toutes les incertitudes qui subsistent et aussi du caractère d’adaptation possible de cette espèce d’insecte.

# Disturbance-driven northwards spread of European beech in Southern Sweden

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It is assumed that European beech is increasing its competitive abilities towards Norway spruce at its northern range margins due to climate change. Studies in three old-growth mixed forests of beech and spruce, situated near the northern beech margin, were conducted to reveal competitive dynamics between both species under natural forest dynamics. We performed analyses on stand structure development (2004/2005 and 2011), on competitive interaction, on tree decline dynamics after the storm “Gudrun”(2005), the subsequent drought (2006), and bark beetle outbreak (2007 ff.) as well as dendroecological studies on diameter growth of beech and spruce. It became apparent that European beech gained competitive vigour compared to dominating Norway spruce during the last decades, affiliated with an increased warming. However, distinct disturbances like wind throw, drought and bark beetle attacks which affected nearly solely spruce, may play the major role for beech’s competitive success and it’s northwards spreading in the future.

# Extension vers le Nord du hêtre dans le sud de la Suède en lien avec le régime de perturbations

Le hêtre augmenterait ses capacités de compétition vis-à-vis de l'épicéa commun à sa lisière Nord en raison du changement climatique. Les études menées dans trois forêts mélangées anciennes de hêtre et d'épicéa, situées à proximité de la lisière Nord du hêtre, révèlent les dynamiques compétitives entre les deux essences dans un contexte de dynamiques forestières naturelles. Nous avons effectué des analyses du développement de la structure des peuplements (2004/2005 et 2011), de l'interaction compétitive, de la dynamique de mortalité des arbres après la tempête « Gudrun » (2005), de la sécheresse qui a suivi (2006), et de l'invasion de scolytes (2007) ainsi que des études dendroécologiques sur la croissance du diamètre des hêtres et des épicéas. De toute évidence, au cours des dernières décades, le hêtre européen gagne en vigueur compétitive par rapport à l'épicéa commun dominant, en lien avec le réchauffement climatique. Néanmoins, des perturbations distinctes comme les chablis, la sécheresse et les attaques de scolytes qui n'ont presque touché que l'épicéa peuvent jouer un rôle majeur dans le succès compétitif du hêtre et dans son extension vers le Nord à l'avenir.

# Likelihood of improving climatic conditions for the pine-tree lappet moth (Dendrolimus pini) in Scotland: an examination of the probabilistic climate change projections for the UK

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Although pine-tree lappet moth (Dendrolimus pini) is a common and widespread moth of the palaearctic region, it has not been considered native to the UK, where until recently only a few records of males occurred in England, leading to the assumption that the moth was a rare and infrequent vagrant. In 2004-5, the moth was discovered in Scots pine forest in north-east Scotland, and subsequent research has shown the establishment of a small breeding population. This has alerted: conservationists to the possibility that the moth might be native but previously overlooked, and foresters to the potential damage to Scots pine forests if the moth has colonized as a result of recent changes in the climate. We present a climatic study of the region in Scotland where the new population has been found, focusing on recent changes in the climate and examining the projected decadal changes over the coming century. The study makes use of the new probabilistic climate projections published in the UK (UKCP09), and in particular shows how current and future projections of a climatic index (Seljaninov's hydro-thermal coefficient) can be used to assess the risk that pine-tree lappet moth population outbreaks may pose. We show how the projected changes in climate might improve conditions for pine-tree lappet moth in eastern Scotland and compare these to contemporary climatic conditions in Poland where lappet moth is a serious forest pest. The results show an increasing likelihood of suitable summer climatic conditions for pine-tree lappet moth outbreaks in Scotland in future decades. The study is now providing evidence for the management outbreak team in Scotland. This is offered as a contribution from the COST Action FP0703 ECHOES Working Group 1 "Impacts" (http://www2.gip-ecofor.org/echoes).

# Probabilité d'une amélioration des conditions climatiques pour le bombyx du pin (Dendrolimus pini) en Écosse : examen des projections probabilistes du changement climatique pour le Royaume-Uni

Bien que le bombyx du pin (Dendrolimus pini) soit une chenille commune et répandue de la région paléarctique, elle n'est pas considérée comme native au Royaume-Uni. Jusqu'à récemment, seuls quelques signalements de mâles avaient été référencés en Angleterre, ce qui laissait à penser que la chenille était un vagabond rare et peu fréquent. En 2004-5, elle a été découverte dans une pinède du nord-est de l'Écosse, et des études ultérieures ont révélé l'établissement d'une petite population reproductrice. Ce phénomène a sensibilisé les conservationnistes à la possibilité que le bombyx aurait pu être natif mais ignoré au préalable, et les forestiers aux dommages éventuels sur les pinèdes écossaises s'il les colonisait à la suite des récents changements survenus dans le climat. Nous présentons une étude climatique de la région d'Écosse, où ont été découvertes ces nouvelles populations, en nous concentrant sur les récents changements climatiques et en examinant les changements projetés par décade au cours du siècle prochain. L'étude s'appuie sur les nouvelles projections climatiques probabilistes publiées au Royaume-Uni. (UKCP09). Elle montre en quoi les projections actuelles et futures d'un indice climatique (coefficient hydrothermique de Seljaninov) peuvent servir à évaluer le risque posé par une invasion éventuelle du bombyx du pin. Nous montrons en quoi les changements climatiques projetés pourraient améliorer les conditions pour le bombyx dans l'est de l'Écosse et nous les comparons avec les conditions climatiques actuelles en Pologne, où le bombyx constitue un nuisible forestier sévère. Les résultats indiquent une probabilité en hausse de conditions climatiques estivales adaptées à des invasions de bombyx du pin dans les prochaines décades en Écosse. Ils apportent également des preuves pour l'équipe de gestion des invasions en Écosse. Cette étude est une contribution du Groupe de travail 1 « Impacts » Action COST FP0703 ECHOES.

# MANAGEMENT FOR ADAPTATION 2

**Tuesday 22 May**

**14:00 – 15:45. Scientific Parallel Sessions 4**

# Adaptive forest fire management in the Mediterranean Europe

Yannis RAFTOYANNIS - Department of Forestry, TEI Lamias - Greece
Susanna NOCENTINI - Dipartimento di Economia, Ingegneria, Scienze e Tecnologie Agrarie e Forestali, Università degli Studi di Firenze – Italy
Enrico MARCHI - Dipartimento di Economia, Ingegneria, Scienze e Tecnologie Agrarie e Forestali, Università degli Studi di Firenze – Italy
Rafael CALAMA SAINZ - Dpto. Selvicultura y Gestión Forestal, CIFOR-INIA – Spain
Carlos GARCIA GUEMES - Servicio Territorial de Medio Ambiente. Junta de Castilla y León – Spain

Due to frequency of occurrence and the magnitude of effects on the environment, health, economy, and security, forest fires have increasingly become a major subject of concern for decision makers, firefighters, researchers, and citizens in general. Many countries of southern Europe are facing forest fires in conditions that were not known before and the future climate scenarios foresee more intense and more frequent forest fires. Improved forest fire prevention and management are needed in order to move from emergency to an integrated adaptive approach linking fuel management with fire suppression to help reduce the risks posed by fire under future climatic conditions. Adaptation options related to forest fires and climate change include fuel management and modification of forest structure, change of species composition, investments in infrastructure, training and equipment, public education, local planning and active post-fire management. However, the adaptive capacity is strongly limited in the Mediterranean region where large forest areas are only extensively managed or unmanaged. As a result, there are few active fire management options while the maintenance and enhancement of ecosystem resilience can be an appropriate adaptation strategy. A critical review of adaptive fire management measures will be presented with particular reference to experiences and results from European Mediterranean countries. The results of a survey on the perspectives of forest practitioners on adaptive fire management options will also be presented. This contribution is an activity of the Working Group 2 “Adaptation”, within the COST Action FP0703 “Expected Climate Change and Options for European Silviculture”.

## Gestion forestière adaptative face aux incendies en Europe méditerranéenne

En raison de leur fréquence et de l'amplitude de leurs effets sur l'environnement, la santé, l'économie et la sécurité, les feux de forêts deviennent un sujet de préoccupation croissante pour les décideurs, les pompiers, les chercheurs et les citoyens de manière générale. De nombreux pays d'Europe du Sud affrontent des feux de forêts dans des conditions jamais rencontrées et les futurs scénarios climatiques prévoient une hausse de leur fréquence et de leur intensité. Une gestion forestière et une prévention améliorées sont nécessaires afin de passer d'une approche d'urgence à une approche intégrée adaptative qui relie la gestion des combustibles à la suppression des incendies pour réduire les risques associés dans les futures conditions climatiques. Les options adaptatives liées aux feux de forêts et au changement climatique incluent la gestion des combustibles et la modification de la structure forestière, des changements dans la composition des essences, des investissements dans les infrastructures, la formation et les équipements, l'éducation du public, la planification locale et une gestion post-incendie active. Néanmoins, la capacité adaptative est fortement limitée dans la région méditerranéenne, où de vastes zones forestières sont uniquement gérées de manière extensive ou non gérées. Peu d'options de gestion active des incendies sont donc disponibles, tandis que la maintenance ou le renforcement de la résistance des écosystèmes peut servir de stratégie d'adaptation appropriée. Une analyse critique des mesures d'adaptation de la gestion adaptative des incendies sera présentée en mentionnant particulièrement les expériences et les résultats des pays méditerranéens d'Europe. Les résultats d'une étude sur l'avis des experts forestiers en matière d'options de gestion adaptative des incendies seront également présentés. Cette contribution est une activité du Groupe de travail 2 « Adaptation » de l'Action COST FP0703 ECHOES.

# Optimizing the management responses to the climate change in the boreal conditions – methods and findings

Seppo KELLOMÄKI - University of Eastern Finland - Finland
Timo PUKKALA - University of Eastern Finland - Finland
Heli PELTOLA - University of Eastern Finland – Finland

Model approach was developed for the northern boreal forests in the Motive Project for identifying a management when the timber production and carbon storing are aimed in the management under the climate change. In this context, the eco-physiological responses of trees to the climate change were transferred to the NewStand simulation–optimization system based on the following assumptions: (i) responses are species-specific, (ii) the responses are specific to maturity (size) of trees, (iii) the response are specific to the position of trees in the stand, and (iv) the responses are specific to the site fertility (site type). Consequently: ΔGrowth (ΔD, ΔH) = f(climate change, tree species, maturity (H, D), position, site type) (1) where D is the diameter and H is the height of a tree. The transfer of climate change impacts into NewStand is based on the relative in growth (ΔG(REL)), which the change in climate (temperature, precipitation, $CO_2$) is doing in relation to the growth under the current climate. The process-based model FinnFor was used to generate the data used to identify the relative change in growth due to climate change following Equation (1). The model utilizes the main physiological (photosynthesis, respiration, transpiration, water and nutrient uptake) in calculating the growth of trees. Depending on the physiological and growth processes on the hourly, daily and annual basis, the model is parameterized for the main trees species in Finland. Climate change increased the radial and height growth of Scots pine in similar way from 0.36% per year up to 0.59% in such a way that the increase was larger on poor sites compared to that in the fertile sites. The same pattern held for Norway spruce and birch, but in these cases the increase was smaller that of Scots pine, and the increase in the height growth was smaller than that in the radial growth. Based on the NewStand simulation–optimization system, such a management schedule can be selected, which produces the most preferred distribution of outcomes (e.g. has the highest NPV). The outcome of optimization will be a rule, that tells to landowner how the optimal cutting decision depends of stand structure and timber prices (i.e., when the right moment to cut the stand is and how it should be cut). Examples on the model output in terms of proper management under climate change are presented.

## Optimisation des réponses de gestion au changement climatique en conditions boréales – méthodes et résultats

Une modélisation a été développée pour les forêts boréales septentrionales du projet MOTIVE afin d'identifier une gestion appropriée pour la production de bois et le stockage carbone dans le contexte du changement climatique. Les réponses écophysiologiques des arbres au changement climatique ont été transférées dans le nouveau système d'optimisation-simulation NewStand sur la base des hypothèses suivantes : (i) les réponses sont spécifiques aux essences, (ii) les réponses sont spécifiques à la maturité (taille) des arbres, (iii) les réponses sont spécifiques à la position des arbres dans le peuplement, et (iv) les réponses sont spécifiques à la fertilité du site (type de site). Par conséquent : ΔCroissance (ΔD, ΔH) = f(changement climatique, essence, maturité (H, D), position, type de site) (1) où D représente le diamètre et H la hauteur d'un arbre. Le transfert des impacts du changement climatique sur NewStand se fonde sur la variation de croissance (ΔC(VAR)), que le changement climatique (température, précipitations, $CO_2$) génère en lien avec la croissance sous le climat actuel. Le modèle fondé sur les processus FinnFor a servi à générer les données utilisées pour identifier la variation relative dans la croissance en raison du changement climatique suite à l'équation : (1). Le modèle s'appuie sur les principales caractéristiques physiologiques (photosynthèse, respiration, transpiration, absorption d'eau et de nutriments) pour le calcul de la croissance des arbres. En fonction des processus physiologiques et de croissance sur une base horaire, quotidienne et annuelle, le modèle est paramétré pour les principales essences d'arbres en Finlande. Le changement climatique a augmenté la croissance radiale et en hauteur du pin de manière similaire de 0,36 % par an jusqu'à 0,59 % de sorte que l'augmentation était plus importante sur les sites plus pauvres que les sites fertiles. Le même schéma se confirme pour l'épicéa et le bouleau, mais dans ce cas l'augmentation est inférieure à celle constatée pour le pin d'Écosse et l'augmentation de la croissance en hauteur est inférieure à celle de la croissance radiale. Sur la base du système de simulation-optimisation NewStand, un calendrier de gestion peut être sélectionné, qui produit la distribution privilégiée des résultats (par ex. celle qui affiche la Valeur de production nette la plus élevée). Les résultats de l'optimisation servent de recommandation pour le propriétaire qui sait que la coupe optimale dépend de la structure du peuplement et des prix du bois d'œuvre (c'est-à-dire, quand le moment est opportun pour abattre le peuplement et comment il doit être coupé). Des exemples de contributions du modèle pour la gestion appropriée dans le contexte du changement climatique sont également présentés.

# Adapting forests to climate change in the French Mediterranean mountains: how far forest management can facilitate species succession, consider growth potential modification, and ensure the continuity of some ecosystem services

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For. Eng. Jean LADIER - ONF (National Forest Service) R&D - Avignon - France
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As the climate - a major component of site quality - is changing, the distribution of site characteristics is shifting in space. As a consequence, many forest stands are currently severely impacted and even larger areas are threatened. Foresters try to prevent catastrophic decline by changing target species for forest management, according to the new, continuously moving, site conditions that are expected. In situations where stand survival is not at risk, climate warming at least modifies the growth potential : it is usually decreased at low elevation (namely through reduced water supply) and can increase at higher altitude (owing to the alleviation of limitation by winter coldness). While silvicultural guidelines are usually designed for several fixed and steady site index classes, a given stand is indeed likely to experience varying site conditions along its lifespan. The study aims to investigate how far different forest management strategies can facilitate and increase speed of species succession and to propose a decision support system to help developing anticipative management dealing with the risk of decline and the continual change of growth potential. For this purpose, we use (i) a forest dynamics model and simulation tool dedicated to the context of pine forests maturation and silver fir and beech colonization, (ii) GIS maps of climate variables related to elevation, of climate change according to IPCC scenarios, (iii) and of topography and soil characteristics likely to act as compensating factors. Changing to better adapted species seems to be achievable in the Mediterranean mountain forests, for example in south-eastern France, by taking advantage of colonization trends exhibited by shade-tolerant species spreading under pine stands where site conditions are - and will probably remain - suitable, and conversely by favoring pine species where the future site conditions will become critical for beech and silver fir and, thus, should reverse their current expansion trend. In a safe but changing context, adapting the silviculture applied to any stand is feasible through a new type of flexible guidelines taking into account the climate-dependent growth potential as estimated at each step. We present a simulation tool making it possible to tune silviculture (at tree and stand level) and to plan forest management (at the landscape level) in order to assist species transition, to deal with time-varying site conditions, and to ensure forest permanence, hence sustaining some forest ecosystem services of major importance in the study area (timber, soil protection ...)

## Adapter les forêts au changement climatique dans les montagnes méditerranéennes françaises : en quoi la gestion forestière peut faciliter la succession des essences, tenir compte de la modification de croissance potentielle et garantir la continuité de certains services écosystémiques.

Alors que le climat – aspect majeur de la qualité stationnelle – évolue, la distribution des caractéristiques du site mute dans l'espace. Par conséquent, de nombreux peuplements forestiers sont à l'heure actuelle lourdement touchés. De larges zones sont même menacées. Les forestiers tentent d'empêcher un dépérissement catastrophique en modifiant les essences cible pour la gestion forestière, en fonction de conditions de site nouvelles et en mutation permanente. Dans les situations où la survie du peuplement n'est pas en jeu, le réchauffement climatique modifie au moins le potentiel de croissance : celui-ci enregistre en général une baisse à faible altitude (principalement en raison du moindre approvisionnement en eau) et peut augmenter à des altitudes plus élevées (en raison de la réduction des contraintes liées à la rigueur hivernale). Si les recommandations sylvicoles sont en général conçues pour plusieurs catégories d'indices de station fixes et constantes, un peuplement donné est susceptible de rencontrer des conditions variables tout au long de sa durée de vie. L'étude cherche à comprendre en quoi les stratégies de gestion forestière peuvent faciliter et améliorer la rapidité de succession des essences. Elle vise à proposer un système d'aide à la prise de décision pour contribuer au développement d'une gestion anticipative qui tienne compte du risque de déclin et du changement continu de potentiel de croissance. À cette fin, nous nous appuyons sur (i) un modèle forestier dynamique et un outil de simulation dédié au contexte de la maturation des pinèdes et de la colonisation de sapin blanc et de hêtre, (ii) des cartes GIS des variables climatiques liées à l'élévation, du changement climatique en fonction des scénarios GIEC, (iii) et sur la topographie et les caractéristiques du sol susceptibles de servir de facteurs de compensation. Changer pour des essences mieux adaptées semble être réalisable dans les forêts de montagne méditerranéennes, par exemple dans le sud-est de la France, en tirant profit des tendances de colonisation présentées par les essences tolérantes à l'ombre qui se développent sous les essences de pins, là où les conditions du site sont – et resteront probablement – adaptées, et inversement, en favorisant les essences de pins là où les futures conditions du site deviennent critiques pour le sapin blanc et le hêtre, entraînant ainsi une inversion de leurs tendances d'expansion actuelles. Dans un contexte sécurisé mais évolutif, adapter la sylviculture appliquée à chaque peuplement est faisable par le biais d'un nouveau type de recommandations flexibles qui tiennent compte du potentiel de croissance dépendant du climat, évalué à chaque étape. Nous présentons un outil de simulation qui rend possible une personnalisation de la sylviculture (au niveau de l'arbre et du peuplement) et une planification de la gestion forestière (au niveau du paysage) afin d'aider à la transition, de prendre en compte les conditions stationnelles variables dans le temps et de garantir la permanence des forêts, et ainsi de soutenir certains services écosystémiques d'importance majeure dans la région d'étude (bois d'œuvre, protection des sols, etc.).

## Exploring adaptive management options under climate change in a biosphere reserve

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In a biosphere reserve nature conservation is a key issue. Management for other ecosystem services is possible within specific limits set by nature conservation. In the future the provision of these goods and services may be affected by climate change. The particular challenge to maintain demanded ecosystem services lies in the potential trade-offs between nature conservation values and other services such as timber production and recreation. The objective of the current study was to derive adaptive management options on the basis of a vulnerability assessment. The study region is defined as the forest area owned by the Austrian Federal Forests (ÖBf) within the UNESCO biosphere reserve “Biosphärenpark Wienerwald” near the city of Vienna. The study region extends over an area of 33000ha and is covered by beech dominated mixed forests. Of particular interest are several wood pecker species and maintenance of suitable habitat structures is of paramount importance. To simulate pathways of future development of the study region the forest ecosystem model PICUS 1.43 was used. Basic information about sites, stand types and management were provided by the Austrian Federal Forests (ÖBf). For the analysis a baseline climate and three transient climate change scenarios based on the emission scenarios A1B, A2 and B1 were used. First ecosystem service vulnerability under business as usual (BAU) management was assessed for three time horizons (2001-2020, 2021-2050, 2051-2100) to detect vulnerable site-stand combinations. In a second step adaptive management options (AM) were developed and residual vulnerability analyzed. To get a feasible definition of vulnerability a group of stakeholders including staff of the Austrian Federal Forests, the biosphere reserve management, nature conservation NGOs, tourism experts and the forest administration service derived and weighted a set of indicators during a workshop. The stakeholders were also included in the development of AM. The results of the BAU analysis showed strong differences in the development of the indicators under climate change depending on stand and site type. Especially stands with a high share of spruce in combination with dry site conditions were highly vulnerable. Furthermore trade-offs between different indicators like productivity vs. biodiversity and wood pecker habitat were detected. However, the AM results indicated that adaptive management concepts are able to provide the required ecosystem goods and services in the biosphere reserve “Biosphärenpark Wienerwald” under the analyzed climate change scenarios.

## Exploration des options de gestion adaptative face au changement climatique d’une réserve de biosphère

Dans une réserve de biosphère, la protection de la nature est une question clé. La gestion des autres services écosystémiques est possible dans les limites spécifiques définies par la protection de la nature. À l’avenir, le changement climatique pourrait avoir un impact sur ces biens et ces services. Le défi particulier pour maintenir les services écosystémiques demandés repose sur les échanges potentiels entre les valeurs de protection de la nature et les autres services comme la production de bois d’œuvre et les loisirs. L’objectif de cette étude était de dériver des options de gestion adaptative sur la base d’une évaluation de la vulnérabilité. La région étudiée est définie par l’aire forestière détenue par l’office autrichien des forêts (ÖBf) au sein de la réserve de biosphère de l’UNESCO « Biosphärenpark Wienerwald » dans les environs de Vienne. Elle s’étend sur 33 000 ha et est couverte de forêts mixtes dominées par le hêtre. Plusieurs espèces de piverts sont remarquables et la protection de leur habitat est d’importance capitale. Pour simuler des pistes de futur développement de la région étudiée, le modèle d’écosystème forestier PICUS 1.43 a été utilisé. Les informations fondamentales sur les sites, les types de peuplements et leur gestion ont été fournies par ÖBf. Pour l’analyse, un climat de référence, et trois scénarios de changement climatique fondés sur les scénarios d’émissions A1B, A2 et B1 ont été retenus. Premièrement, la vulnérabilité des services écosystémiques dans le cadre d’une gestion routinière a été évaluée pour les trois horizons temporels (2001-2020, 2021-2050, 2051-2100) afin de détecter les combinaisons site-peuplement vulnérables. Dans un deuxième temps, des options de gestion adaptative ont été développées et la vulnérabilité résiduelle analysée. Pour obtenir une définition concrète de la vulnérabilité, un groupe de parties prenantes, composé entre autres de personnels d’ÖBf, de la direction de la réserve de biosphère, d’ONG de protection de la nature, d’experts touristiques et des services d’administration de la forêt a dérivé et pondéré un panel d’indicateurs lors d’un atelier. Les parties prenantes ont également participé au développement des options de gestion adaptative. L’analyse des pratiques routinières a révélé de fortes différences du développement des indicateurs dans le contexte du changement climatique, en fonction du peuplement et du type de site. Plus particulièrement, les peuplements avec une forte proportion d’épicéa associée à des conditions de site arides se sont révélés très vulnérables. En outre, des échanges entre les différents indicateurs, comme la productivité par rapport à la biodiversité et l’habitat des piverts, ont été détectés. Néanmoins, les résultats des options de gestion adaptative confirment que ces concepts sont en mesure de fournir les biens et services écosystémiques nécessaires dans la réserve de biosphère « Biosphärenpark Wienerwald » dans le contexte des scénarios de changement climatique analysés.

**Wind damage probability-reducing forest management and its effects on recreation- and life-style values, and yield**

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Owning a forest in Sweden has been characterized as a life-style project (Törnqvist, 1995). For example, performing some of the forest operations by oneself in one's own forest is often highly valued as is the forest as a place for recreation. Indeed, the financial return from forestry amounts to only a minor part of the average household income. According to south Swedish private individual forest owners damage by wind is one of the worst risks to their forestry (Blennow, 2008). It is the risk that increases the most due to climate change according to forest owners who have adapted to climate change (Blennow, 2011). Hence, it is relevant to evaluate how the probability of wind damage may be modulated by adapting the forest management regime, and how the adaptation affects the provision of recreation- and life-style values, and yield. We designed an adaptive forest management programme aiming at reducing the probability of wind damage. The adapted management programme was constructed in consultation with a stakeholder reference group and includes reduced length of the rotation period, reduction of the maximum age at which commercial thinning is carried out, and use of deciduous tree species in regeneration at wind exposed locations. We used it in simulations of future states of the forest under current and changed climate. The Forest Time Machine was used to project the state of the forest into the future (Andersson et al., 2005), to keep track of the forestry operations applied and the yield during the course of the simulations. Climate change in terms of output for the CLM/ECHAM5 model under the A1B emission scenario affected the site index. The sensitivity of the site index to climate change was modeled using the FinnFor model (Kellomäki & Väisänen, 1997: Matala et al., 2005). The probability of wind damage was calculated per forest stand in a landscape setting using the WINDA-GALES system of models (Blennow et al., this conference). Adaptive feed-back during simulations was acquired through evaluation of consecutive forest states with respect to the probability of wind damage. Indicators of recreation (Lindhagen, 2005) and life-style values in terms of management intensity, and the probability of wind damage were estimated on output future states of the forest. The results have been compared to simulated values of the currently recommended forest management regime for the region. References: Andersson, M., Dahlin, B., Mossberg, M., 2005. The forest time machine—a multi-purpose forest management decision-support system. Comput Electron Agric 49:114–128. Blennow, K., 2008. Risk management in Swedish forestry – Policy formation and fulfillment of goals. Journal of Risk Research 11:237-254. Blennow, K., 2011. Adaptation of forest management to climate change among private individual forest owners in Sweden. Forest Policy and Economics. In press. doi:10.1016/j.forpol.2011.04.005 Blennow, K., Gardiner, B., and Mossberg M., 2012. The WINDA-GALES wind damage probability planning tool. This conference. Kellomäki, S. and Väisänen, H. 1997. Modelling the dynamics of the boreal forest ecosystems for climate change studies in the boreal conditions.

## Gestion forestière réduisant la probabilité des dommages dus au vent et conséquences sur les valeurs mode de vie et loisirs, et sur le rendement

Détenir une forêt en Suède a été décrit comme étant un projet de mode de vie (Törnqvist, 1995). Ainsi, effectuer soi-même certaines opérations forestières dans sa propre forêt est souvent très apprécié car celle-ci est considérée comme un espace de loisirs. De fait, les retours financiers de la sylviculture ne représentent qu'une part mineure du revenu moyen des foyers. Selon les propriétaires individuels de forêts du sud de la Suède, les dommages dus au vent sont l'un des pires risques encourus par leur propriété (Blennow, 2008). Il s'agit du risque qui augmente le plus en raison du changement climatique selon les propriétaires forestiers qui se sont adaptés au changement climatique (Blennow, 2011). Par conséquent, évaluer comment la probabilité des dommages dus au vent peut être modulée en adaptant le régime de gestion forestière est une mission pertinente, de même que comprendre en quoi l'adaptation a un impact sur la fourniture de services de loisirs et de mode de vie, et sur le rendement. Nous avons conçu un programme de gestion forestière adaptative qui vise à réduire la probabilité des dommages dus au vent. Ce programme a été conçu en consultation avec un groupe de parties prenantes de référence et inclut une réduction de la durée de la période de rotation, la réduction de l'âge maximum auquel l'éclaircissage commercial est effectué, et l'utilisation d'essences caduques dans la régénération des sites exposés au vent. Nous l'avons utilisé pour des simulations des futurs états des forêts dans le climat actuel et futur. La Forest Time Machine a été utilisée pour projeter l'état de la forêt dans l'avenir (Andersson et al., 2005), et assurer un suivi des opérations forestières appliquées et du rendement. Le changement climatique en termes de contribution du modèle CLM/ECHAM5 sous le scénario d'émissions A1B a affecté l'indice de station. Sa sensibilité au changement climatique a été modélisée grâce au modèle FinnFor (Kellomäki & Väisänen, 1997: Matala et al., 2005). La probabilité des dommages dus au vent a été calculée par peuplement forestier dans un environnement paysager en utilisant le système de modèles WINDA-GALES (Blennow et al., cette conférence). Le feedback adaptatif lors des simulations a été obtenu par l'évaluation des états consécutifs des forêts en matière de probabilité des dommages dus au vent. Les indicateurs de loisirs (Lindhagen, 2005) et les valeurs de mode de vie en termes d'intensité de gestion et la probabilité des dommages dus au vent ont été évalués sur les futurs états produits des forêts. Les résultats ont été comparés aux valeurs simulées du régime de gestion recommandé à l'heure actuelle pour la région.

## Close-to-nature silviculture as adaptation strategy to climate change

Dr. Peter BRANG - WSL Swiss Federal Research Institute of Forest, Snow and Landscape Research - Switzerland
Prof. Jorgen BO LARSEN - University of Copenhagen - Denmark
Prof. Peter SPATHELF - Faculty of Forest and Environment , University of Applied Sciences, Eberswalde – Germany

In Central Europe, an increasing number of practitioners and forest administrations claim that close-to-nature silviculture (CNFS) is the best solution to cope with future climate change. CNFS originates in the 19th century, has been widely practiced since in some regions of Europe, and different types of CNFS have developed, ranging from small-scale plentering over group selection to shelterwood systems. In this paper, we investigate the opportunities and limitations of CNFS as a means to adapt forests to climate change. Our approach consists in checking to what degree CNFS systems make use of management principles which are considered as effective for increasing the adaptive capacity of Central European forests to a changing climate. In general, CNFS is effectively increasing the adaptive capacity of Central European forests to a changing climate. In particular, it makes extensive use of site-adapted forest management, promotes structural diversity and individual resistance to biotic and abiotic stressors, and strives to maintain the forest interior climate and soil fertility. However, some deficits exist in implementing the principles ‘increase tree species diversity’, ‘maintain and increase genetic variation’, and ‘substitute high-risk stands’. To address these deficits, CNFS should in particular make increased use of i) a larger variation in regeneration methods which helps to include light-demanding tree species, and of ii) non-native species and non-local provenances. This seems easier in silvicultural systems with gap-cutting than in purely single-tree oriented systems. [A paper based on work done in ECHOES, with 15 co.authors]

## Sylviculture proche de la nature en guise de stratégie d’adaptation au changement climatique

En Europe centrale, un nombre croissant d’experts et d’administrations forestières affirment que la sylviculture proche de la nature est la meilleure solution pour faire face au futur changement climatique. Celle-ci puise ses origines dans le XIXe siècle et est largement pratiquée depuis dans plusieurs régions d’Europe. Différentes méthodes ont été développées, qui vont de la sélection à petite échelle aux systèmes de bois d’habitation. Cette présentation étudie les opportunités et les limites de ce type de sylviculture comme moyen d’adapter les forêts au changement climatique. Notre méthode consiste à vérifier dans quelle mesure le système de sylviculture proche de la nature utilise des principes de gestion considérés comme efficaces pour améliorer la capacité adaptative des forêts d’Europe centrale au changement climatique. En règle générale, cette sylviculture améliore efficacement cette capacité. Plus particulièrement, elle utilise largement la gestion forestière adaptée à la station, promeut la diversité structurelle et la résistance individuelle aux facteurs de stress biotiques et abiotiques, et s’efforce de préserver le climat forestier intérieur et la fertilité du sol. Néanmoins, certains déficits existent dans la mise en œuvre des principes « améliorer la diversité des essences », « préserver et renforcer la diversité génétique » et « substituer les peuplements à haut risque ». Pour combler ces déficits, la sylviculture proche de la nature doit particulièrement faire une plus grande utilisation de : i) une plus grande variation des méthodes de régénération, qui contribue à inclure les essences d’arbres peu consommatrices de lumière et ii) les essences non natives et les provenances non locales. Ces principes semblent plus facilement applicables dans les systèmes à trouées sylvicoles que dans les systèmes orientés uniquement « arbre individuel ». [Un article fondé sur le travail effectué dans ECHOES, avec 15 coauteurs]

# MITIGATION 2

**Tuesday 22 May**

**14:00 – 15:45. Scientific Parallel Sessions 4**

## Fuelwood, timber and climate change: Insights from forest sector modeling

Philippe DELACOTE - INRA- Laboratoire d\'Economie Forestière - France
Franck LECOCQ - CIRED - France
Sylvain CAURLA - INRA- Laboratoire d\'Economie Forestière – France
Ahmed BARKAOUI - INRA- Laboratoire d\'Economie Forestière – France

Increased demand for commercial fuelwood is a major trend impacting forest sectors worldwide. In Europe, the share of renewable in final energy consumption is due to increase dramatically to meet the objectives of directive 2009/28/EC, with potentially significant implications for fuelwood markets.Looking forward, it remains unclear whether forest sectors will be able to contribute as much as expected to the overall renewable energy targets. Though from a physical point of view, the resource often appears sufficient to absorb the increased demand, economic availability might be much more limited. Conversely, how increased demand for fuelwood – traditionally a byproduct of timber and sawnwood production – may alter wood markets is subject to discussion. But increase in fuelwood demand cannot be separated from other trends impacting forest sectors, chief among which the attention paid to mitigation to climate change. If climate change mitigation is a rationale for renewable energy targets, it also spurs the development of other policies with implication for forest sectors, notably the valuation of carbon sequestered in standing biomass, via, e.g., Kyoto Protocol Articles 3.3 and 3.4, or voluntary carbon markets. Though currently limited in scope, ambitious forest carbon policies are likely to emerge in the near future – and analyzing the future of forest sectors in terms of carbon balance is already a necessity. We plan to present an overview of the work done in forest modeling on those compeling issues. They approach the problem both at a national scale (Finland, U.S.A, France, Norway) and at infra- and supra-national scales.

## Bois de chauffage, bois d'œuvre et changement climatique : perspectives d'une modélisation du secteur forestier

La demande accrue pour le bois de chauffage est une tendance majeure qui a impact sur le secteur forestier dans le monde. En Europe, la part d'énergies renouvelables devrait augmenter considérablement pour répondre aux objectifs de la directive 2009/28/EC, avec des implications significatives éventuelles pour le marché du bois de chauffage. La capacité du secteur forestier à contribuer autant qu'attendu aux objectifs globaux en matière d'énergie renouvelable reste floue. Bien que, d'un point de vue physique, cette ressource paraisse souvent suffisante pour absorber l'augmentation de la demande, sa disponibilité économique pourrait être bien plus limitée. À l'inverse, comment l'augmentation de la demande en bois de chauffage – traditionnellement un produit dérivé de la production de bois d'œuvre et de bois scié – pourrait modifier les marchés du bois est matière à débat. Mais l'augmentation de la demande en bois de chauffage ne peut pas être séparée des autres tendances qui ont un impact sur le secteur forestier, principalement l'attention portée à la réduction du changement climatique. Si celle-ci justifie les objectifs en matière d'énergie renouvelable, elle stimule également le développement d'autres politiques avec des implications pour le secteur forestier, notamment l'évaluation du carbone séquestré dans la biomasse existante, via, par ex. les articles 3.3 et 3.4 du protocole de Kyoto ou les marchés carbone volontaires. Bien que limitées actuellement en matière de périmètre, d'ambitieuses politiques carbone forestières sont susceptibles de faire leur apparition dans un avenir proche – et l'analyse de l'avenir du secteur forestier en matière d'équilibre carbone est dès à présent une nécessité. Nous prévoyons la présentation d'un aperçu du travail effectué sur la modélisation des forêts sur ces questions stimulantes. Elles approchent le problème à l'échelle nationale (Finlande, États-Unis, France, Norvège) et infra et supranationale.

# The impacts of the Kyoto Protocol on climate change mitigation in boreal forests

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The Kyoto Protocol (KP), a binding treaty for participating developed countries to reduce their greenhouse gas (GHG) emissions in the period 2008-2012, allows the use of forest carbon sequestration in these countries as emission offset to a limited degree. Bioenergy is on the other hand considered an important mitigation option and receives substantial financial support in many of these countries. However, by only increasing the wood energy production without fully using the forests' capacity to sequester carbon, the mitigation potential in the forest sector (i.e., forestry and forest industry including wood energy) is presumably not being utilized; furthermore, the effects of the KP on the overall GHG fluxes in the sector are not clear. A partial equilibrium model of the Norwegian forest sector is used for comparing the GHG fluxes under a continued KP policy to a policy with no cap on forest carbon sequestration (FC policy) and a baseline with no climate policy. The results indicate that a continued KP policy increases offsets in the forest sector more than no policy and more than the FC in the short run, but fails to utilize the carbon sequestration potential in the long run.

## Les effets du protocole de Kyoto sur l'atténuation du changement climatique dans les forêts boréales

Le Protocole de Kyoto (KP) est un traité juridiquement contraignant : les pays développés participants s'engagent à réduire leurs émissions de gaz à effet de serre sur la période 2008-2012, admet, dans certaines limites et pour ces pays, la prise en compte de la séquestration forestière en compensation des émissions. La bioénergie est par ailleurs considérée comme une importante possibilité d'atténuation et reçoit à ce titre un soutien financier substantiel dans nombre de ces pays. Cependant, en se contentant d'accroître la production énergétique à base de bois sans utiliser totalement la capacité qu'a la forêt de séquestrer du carbone, le potentiel d'atténuation de la filière forêt-bois n'est sans doute pas pleinement valorisé. De plus, les effets du Protocole sur l'ensemble des flux du secteur ne sont pas clairs. Un modèle d'équilibre partiel de la filière forêt-bois norvégienne est utilisé pour comparer les flux de gaz à effet de serre dans le cadre d'une politique fondée sur le protocole de Kyoto avec ceux résultant d'une politique tenant compte de la totalité de la séquestration forestière, d'une part, avec ceux d'une situation de référence sans politique climatique, d'autre part. Les résultats montrent qu'une politique continue de type Protocole de Kyoto accroît la compensation dans le secteur forestier plus que l'absence de politique et plus qu'une politique de séquestration en forêt à court terme, mais ne réussit pas à utiliser pleinement le potentiel de séquestration à long terme.

# Sequester or substitute – consequences of the increased production of bioenergy in Finland

Maarit KALLIO - Finnish Forest Research Institute (ECHOES) - Finland
Olli SALMINEN - Finnish Forest Research Institute – Finland

The growth of forests in Finland has accelerated during the last decades exceeding currently 100 million m3 per year. The average total drain has been 68 millions m3 annually in the last decade. This makes forests an important carbon sink. The forest land sequesters annually an amount corresponding to some 50–60% of the national total greenhouse gas emissions. Nevertheless, the Finnish forest and energy policies aim at intensified use of forest biomass. While the forest industry production has shown a declining trend last years, the use of wood for energy has been in increase, largely due to the policies aiming at substituting wood for fossil fuels both in large scale heat and power production and in smaller scale heating applications. We examine the trade off between sequestering carbon to growing forests and substituting fossil fuels by wood biomass in light of the above developments. More precisely, we consider two scenarios. The first one depicts the business as usual case where the use of wood for materials and energy develops freely with no additional policy intervention. In the second scenario, the use of wood in the production of various energy carriers is promoted by any means it takes (increased price of CO2 emission allowances, CO2 taxes, subsidies) to make the recent, rather ambitious policy goals materialize. The regional demand and prices for woody biomass and the increase in the use of bioenergy by 2030 are projected by the Finnish forest sector model, SF-GTM, appended with the production of heat, power and biofuels. These data are fed into the Finnish large-scale forestry model MELA2009 to control the removals and to simulate the consequent development of forest resources and carbon. The projections are evaluated over longer time horizon to separate the long-run and short-run impacts of the increased use of energy wood. Climate is assumed to change as depicted by the scenario A1 of IPPC. In addition to the issue of accumulating forest stocks or substituting wood for fossil fuels, we discuss the costs associated to achieving the targets of energy wood and the impacts of these targets on the forest industry, an important consumer and producer of wood based energy in Finland.

## Séquestration ou substitution – conséquence de l’augmentation de la production de bioénergie en Finlande.

La croissance des forêts en Finlande s’est accélérée durant les dernières décades et dépasse à l’heure actuelle 100 millions de $m^3$ par an. Le décroissement annuel moyen s’élève à 68 millions de $m^3$ dans la dernière décade. Cette donnée fait des forêts un puits carbone important. Les espaces boisés séquestrent chaque année un volume correspondant à environ 50-60 % des émissions nationales de gaz à effet de serre. Néanmoins, la forêt finlandaise et les politiques énergétiques visent à intensifier l’utilisation de la biomasse forestière. Si la production du secteur forestier montre une tendance à la baisse sur les dernières années, l’utilisation de bois pour l’énergie a augmenté, principalement en raison des politiques qui visent à substituer le bois aux combustibles fossiles à la fois pour la production énergétique et calorifique à grande échelle et pour les applications de chauffage à plus petite échelle. Nous examinons les échanges entre la séquestration du carbone dans les forêts en croissance et la substitution des combustibles fossiles par la biomasse bois à l’aune des évolutions mentionnées ci-dessus. Plus précisément, nous envisageons deux scénarios. Le premier décrit une activité inchangée, où l’utilisation du bois pour les matériaux et l’énergie se développe librement sans intervention politique complémentaire. Dans le second scénario, l’utilisation du bois pour la production de divers vecteurs d’énergie est promue par tous les moyens nécessaires (hausse du prix des autorisations d’émissions de $CO_2$, taxes carbone, subventions) pour concrétiser les récents objectifs ambitieux. La demande régionale et les prix pour la biomasse bois, et l’augmentation de l’utilisation des bioénergies d’ici à 2030 sont projetés par le modèle du secteur forestier finlandais, SF-GTM, complété de la production de chaleur, d’électricité et de biocombustibles. Ces données sont alimentées dans le modèle forestier de grande échelle finlandais MELA2009 pour contrôler les suppressions et simuler le développement ultérieur des ressources forestières et du carbone. Les projections sont évaluées à long terme pour distinguer les impacts à court et long terme d’une utilisation accrue de bois d’énergie. Le changement climatique envisagé est celui décrit par le scénario A1 du GIEC. Outre la question de l’accroissement des stocks forestiers ou de la substitution des combustibles fossiles, nous discutons des coûts associés à la réalisation des objectifs en matière d’énergie bois et des impacts de ces objectifs sur l’industrie forestière, un important consommateur et producteur d’énergie bois en Finlande.

# Tool for Simulation of Forest Mitigation Potentials

Dr. Volker, MUES - vTI - Insitute for World Forestry - Germany
Konstantin, OLSCHOSFSKY - vTI - Insitute for World Forestry – Germany

Human action is for the first time in history one of the driving forces behind change in climate. Whereas e.g. increase of drought risk in temperate forests is clearly a dangerous and negative effect of climate warming the same process may lead to an increase in tree growth in mountainous or boreal forests. Natural effects due to climate change are examined at research sites. The ICP Forests monitoring database is a comprehensive source of information on such processes and effects. On one hand forests are affected by climate change and the adaptation of forests is described by models developed on the basis of monitoring data. At the other hand forest management affects those processes and in case of climate change this means mitigation of greenhouse gases. We present an integrated method for the quantification of adaptation and mitigation effects for selected areas. It enables the calculation of various studies which quantify potentials and uncertainties of mitigation measures or of entire forest management scenarios, respectively. The documentation of all driving functions and modeled processes together with powerful statistics on the integrated effects allow for an evaluation of management alternatives.

## Outil de simulation des potentiels d’atténuation de la forêt

Pour la première fois dans l’histoire, l’action de l’homme est l’une des forces motrices du changement climatique. Si l’augmentation du risque de sécheresse dans les forêts tempérées est clairement une conséquence négative et dangereuse du réchauffement climatique, celui-ci pourrait dans un même temps entraîner une augmentation de la croissance des arbres dans les forêts montagneuses ou boréales. Les effets naturels du changement climatique sont étudiés sur les sites de recherche. La base de données de suivi de ICP Forests est une source importante d’informations sur ces processus et ces effets. D’un côté, les forêts sont touchées par le changement climatique et leur adaptation est décrite par les modèles développés sur la base des données de suivi. D’une autre, la gestion forestière a un impact sur ces processus. Dans le cas du changement climatique cela signifie la réduction des gaz à effet de serre. Nous présentons une méthode intégrée pour la quantification des effets d’adaptation et de mitigation des zones sélectionnées. Elle permet le calcul de diverses études qui quantifient le potentiel des mesures de réduction et les incertitudes associées à des scénarios entiers de gestion forestière. Cette documentation de toutes les fonctions motrices et de tous les processus modélisés, associée à de puissantes statistiques sur les effets intégrés, permet l’évaluation des alternatives de gestion.

# DISTURBANCES 2

**Tuesday 22 May**

**16:15 – 18:00. Scientific Parallel Sessions 5**

## Uncertainties of forest risks assessment under climate change

Johannes MERKLEIN - Göttingen University – Germany
Prof. Dr. Oleg PANFEROV - Göttingen University / Bingen University of Applied Sciences - Germany
Claus DOERING - Göttingen University - Germany
Prof. Dr. Alexander KNOHL - Göttingen University – Germany

The changing climate results in changing of atmospheric circulation over the Europe and might result in increasing frequency of extreme weather events. The future and current forest risks analysis under climate scenarios C20, A1B and B1 (1960-2100) downscaled by different regional climate models (CLM, REMO, WETTREG) was carried out with daily time step on examples of various forest ecosystems. The analysis indicated that the projected damage depends on the simultaneous effect of many factors: on the intensity and duration of the extreme event itself in the first place, but also on the structure and state of the ecosystem, tree species, topography, soil properties and conditions. Moreover, it is shown that a simultaneous multi-damage analysis should be performed, as the different damage factors might increase or inhibit the probability of another damage factors. The analyses indicated e.g. the increase of windthrow and insect attack risks for Norway spruce in 21st century but decrease of risks for beech. The simulated management activities demonstrated a potential to mitigate the damage. The investigations demonstrated considerable uncertainties of scenario-driven climate impact studies when applied to real, spatially heterogeneous landscapes. The uncertainties could be attributed to the biases in both global and regional climate models and to insufficient horizontal resolution of regional models. The evaluation studies carried out for the same forests using the measurements of German Weather Service indicated the necessity of implementation of very high resolution process-based land surface models for scenarios downscaling.

## Incertitudes de l'évaluation des risques forestiers dans le contexte du changement climatique

Le changement climatique entraîne une modification de la circulation atmosphérique en Europe, qui pourrait entraîner une hausse de la fréquence des événements météorologiques extrêmes. L'analyse des risques forestiers actuels et futurs dans le cadre des scénarios climatiques C20, A1B et B1 (1960-2100) remis à l'échelle de différents modèles climatiques régionaux (CLM, REMO, WETTREG) a été effectuée à intervalles quotidiens sur différents exemples d'écosystèmes forestiers. L'analyse indique que les dommages projetés dépendent de l'effet simultané de nombreux facteurs : l'intensité et la durée de l'événement météorologique extrême, mais aussi la structure et l'état de l'écosystème, les essences d'arbres, la topographie, les propriétés du sol et ses conditions. En outre, une analyse multidommage simultanée doit être effectuée, car les différents facteurs peuvent augmenter ou atténuer la probabilité d'autres facteurs de dommages. L'analyse indique par ex. l'augmentation des risques de chablis et d'attaques par les insectes pour l'épicéa commun au XXIe siècle mais une baisse du risque pour le hêtre. La simulation des activités de gestion atteste de la possibilité de réduire ces dommages. La recherche révèle des incertitudes considérables en matière d'études d'impact climatique fondées sur les scénarios quand elles s'appliquent à des paysages réels et hétérogènes. Ces incertitudes peuvent être dues à des erreurs dans les modèles climatiques régionaux et globaux et à la résolution horizontale insuffisante des modèles régionaux. L'évaluation menée pour les mêmes forêts utilisant les mesures du Service météorologique allemand indique la nécessité d'une mise en œuvre de modèles de surface fondés sur les processus de très haute résolution pour l'adaptation des scénarios à l'échelle.

# Overview of European forest pest and pathogen population responses to climate change

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Marc KENIS - Cabi Delemont - Switzerland
Jan STENLID - Slu Uppsala – Sweden
Steeve WOODWARD - Univ Aberdeen - United Kingdom
Woiciech GRODZKI - Ibl Krakow – Poland
Leen MORAAL - Alterra Wageningen - Netherlands
Ana RINCON - Csic Madrid - Spain
Herve JACTEL - Inra Pierroton – France

In spite of uncertainty about the impact of climate change on populations of forest pests and pathogens, a number of reviews have been published and in most cases they point to an aggravation of the damage with climate warming. In several cases these reviews rely on observation of an increase of pestilence even when the underlying mechanisms is poorly known or just hypothesized. In addition, there is tendency to confound the slow, progressive increase of temperature with other climatic events that, although linked to climate change, may have more specific and profound effects on the populations. As the most important pests and pathogens of European forests are well-known organisms as it concerns their responses to abiotic factors at both individual and population level, we believe that an approach to the problem based on expert opinion and supported by scientific evidence may provide a way to a better understanding of the relationships between climate change and forest pestilence. This could be used also as a framework for hypothesis formulation and testing with single species or with groups of species sharing the same ecological traits. We collected 59 cases involving 43 different species (21 insects and 22 pathogens) from European forests, with some of the species listed for more than one climate-associated driver or mechanism. The results represents the first step towards identifying key functional traits of insects and pathogens that can be used to define their general functional response groups in relation to climate-associated drivers. These response groups can then be used in modelling of biotic responses to future climate change. We recognise, however, that such generalization should be taken with caution as sometimes species may preserve their individuality even in guilds with homogenous functional traits.

## Aperçu de la réponse au changement climatique des populations de nuisibles et de pathogènes des forêts européennes

Malgré les incertitudes sur l'impact du changement climatique sur les populations de ravageurs et de pathogènes, plusieurs analyses publiées révèlent dans la plupart des cas une aggravation des dommages en raison du réchauffement climatique. Dans plusieurs cas, ces analyses s'appuient sur l'observation d'une augmentation des nuisibles même quand les mécanismes sous-jacents sont peu connus ou fondés sur de simples hypothèses. En outre, on tend à confondre la hausse lente et progressive des températures avec d'autres événements climatiques qui, bien que liés au changement climatique, pourraient avoir des effets plus spécifiques et plus profonds sur les populations. Étant donné que les ravageurs et les pathogènes les plus importants d'Europe sont des organismes bien connus en ce qui concerne leur réponse aux facteurs abiotiques au niveau individuel et de la population, nous pensons qu'une méthode fondée sur l'opinion d'experts et étayée par des preuves scientifiques pourrait fournir un moyen de mieux comprendre les relations entre le changement climatique et les nuisibles forestiers. Elle pourrait également servir de cadre pour la formulation d'hypothèses et pour des essais sur des espèces individuelles ou des groupes d'espèces partageant les mêmes caractéristiques écologiques. Nous avons collecté 59 cas impliquant 43 espèces différentes (21 insectes et 22 pathogènes) des forêts européennes, avec plusieurs espèces listées pour plus d'un facteur ou mécanisme associé au climat. Les résultats représentent la première étape vers l'identification de caractéristiques fonctionnelles clés des insectes et des pathogènes qui peuvent servir pour définir les groupes de réponse fonctionnelle générale aux facteurs associés au climat. Ces groupes de réponses peuvent servir à modéliser les réponses biotiques aux futurs changements climatiques. Nous reconnaissons toutefois que cette généralisation doit être considérée avec précaution car les espèces préservent parfois leur individualité même en association avec des caractéristiques fonctionnelles homogènes.

## Responses of forest pests to climate change: tree resistance and herbivore damage along European elevational gradients

CZWIENCZEK - Ewelina - Poland
FACCOLI - Massimo - Italy
GRODZKI - Wojciech – Poland
JACTEL - Hervé - France
MARINI - Lorenzo - Italy
ROQUES - Alain – France
BATTISTI - Andrea – Italy

Environmental conditions and plant genotype may directly and indirectly influence insect herbivory along elevational gradients. Plant damage is expected to decrease with increasing elevation as temperature declines to suboptimal levels for several temperature-limited forest pests. However, host plant quality may also vary along the gradient either reducing or enhancing leaf quality to insects. As climate change is probably altering both average thermal conditions and plant quality the combined effects on herbivory are still unknown. Hence, the aim of the study was to explain the relationship between altitude (as a proxy for temperature) and tree quality (leaf toughness and C/N ratio) and pest damage along steep elevational gradients. Europe was selected as research area within the 7th FP project BACCARA (Biodiversity and Climate Change: A Risk Analysis) and transects were sampled in six European countries for major tree species (Picea abies, Fagus sylvatica, Pinus sylvestris). Along each transect, we measured leaf toughness, C/N ratio of the leaves and the abundance of pests and pathogens. We used linear mixed model to test the effect of elevation on toughness, C/N ratio and damage. We found a general trend of decreasing damage and increasing leaf toughness towards the upper part of the elevation gradient. However, the response seemed to be species-specific. Conifer species consistently presented a negative toughness–elevation relationship while the pattern for broadleaves was less clear. Different guilds of herbivores responded also differently showing both negative and neutral relationships with elevation. No clear association was found between toughness and herbivore damage and C/N ratio. These results suggest that the main driver of leaf toughness and damage seems to be temperature. Considering future climate change scenarios, increasing temperatures will probably lead to less resistant trees and more aggressive insects and pathogens. The relative importance of the two processes, however, still needs to be clarified.

## Réponse des ravageurs forestiers au changement climatique : résistance des arbres et dommages des herbivores sur des gradients altitudinaux européens

Les conditions environnementales et le génotype des plantes peuvent avoir une influence directe et indirecte sur les insectes herbivores le long de gradients altitudinaux. Pour plusieurs nuisibles forestiers contraints par la température, les dommages sur les plantes devraient décroître avec l'augmentation de l'élévation alors que la température descend sous les niveaux optimaux. Néanmoins, la qualité des plantes hôtes peut également varier le long du gradient et réduire ou renforcer la qualité foliaire pour les insectes. Alors que le changement climatique modifie probablement à la fois les conditions thermiques et la qualité des plantes, les effets combinés sur les herbivores restent inconnus. Par conséquent, cette étude vise à expliquer la relation entre altitude (comme donnée indirecte de température) et qualité des arbres (résistance des feuilles et ratio carbone/azote) et dommages des nuisibles le long de gradients altitudinaux escarpés. L'Europe a été retenue comme aire de recherche au sein du projet BACCARA – dans le cadre du FP7 de l'EU- (Biodiversité et changement climatique : analyse des risques) et des transects échantillonnés sur six pays majeurs pour les principales essences d'arbres (Picea abies, Fagus sylvatica, Pinus sylvestris). Sur chaque transect, nous avons mesuré la résistance des feuilles, leur ratio carbone/azote et l'abondance de ravageurs et de pathogènes. Nous avons utilisé un modèle mixte linéaire pour éprouver l'effet de l'élévation sur la résistance, le ratio carbone/azote et les dommages. Nous avons détecté une tendance générale de baisse des dommages et d'augmentation de la résistance vers la partie la plus élevée du gradient altitudinal. Néanmoins, la réponse semble être spécifique à l'essence. Les essences de conifères présentent constamment une relation résistance-élévation négative tandis que le schéma des feuillus est moins marqué. Différentes associations d'herbivores réagissent également de manière différente en montrant une relation négative ou neutre à l'élévation. Aucune association claire n'a été découverte entre la résistance et les dommages des herbivores et le ratio carbone/azote. Ces résultats suggèrent que le principal facteur de résistance des feuilles et de dommages semble être la température. En tenant compte des différents scénarios climatiques, la hausse des températures entraînera probablement des arbres moins résistants et des insectes et des pathogènes plus agressifs. L'importance relative de ces deux processus reste toutefois à clarifier.

## Forest insects and climate change: Can management mitigate the risks?

Christer BJÖRKMAN - Swedish University of Agricultural Sciences - Sweden
Maartje KLAPWIJK - Swedish University of Agricultural Sciences - Sweden
Ida KOLLBERG - Swedish University of Agricultural Sciences – Sweden
Helena BYLUND - Swedish University of Agricultural Sciences – Sweden

Based on previous experience and common knowledge on how insect performance is dependent on temperature it is commonly anticipated that the ongoing climate change will lead to more frequent and severe insect pest problems in forests. However, up to now the evidence supporting this notion is meager despite 50 years of global warming. It is poorly understood why warmer climate has not resulted into expected increase in levels of forest damage caused by insects. Here we present observational (time series) and experimental data that aims at increasing our understanding the mechanisms behind insect outbreaks. One approach is to compare time series data of forest insect species that share many life history traits but that differ in critical traits. Data from Hungary collected from 1961-2009 divided into geographical regions with different forest types were used in these analyses. Another approach is to estimate the relative role of bottom-up (plant quality) and top-down (natural enemies) in different climates and different forest management regimes. Our study system is the widely spread needle-eating pest Neodiprion sertifer (the European pine sawfly). Based on our findings and published knowledge we discuss (1) whether the risk for insect outbreaks is affected by climate change or not and (2) whether forest management can be used to mitigate the risks for insect damage.

# Insectes forestiers et changement climatique : la gestion peut-elle réduire les risques ?

Sur la base d'expériences antérieures et des connaissances communes sur la manière dont la performance des insectes dépend de la température, on considère en général que le changement climatique en cours va générer des invasions des forêts par les insectes plus fréquentes et plus sévères. Pour l'heure, les preuves de ce phénomène restent toutefois maigres malgré 50 ans de réchauffement climatique. Pourquoi le réchauffement n'a pas entraîné l'augmentation attendue des dommages causés par les insectes dans les forêts est un phénomène mal compris. Nous présentons ici des données d'observations (séries temporelles) et expérimentales qui visent à améliorer notre compréhension des mécanismes à l'œuvre dans les invasions d'insectes. Notre approche compare les données des séries temporelles des espèces d'insectes forestiers qui partagent de nombreuses caractéristiques historiques mais qui diffèrent par leurs caractéristiques fondamentales. Ces analyses s'appuient sur des données hongroises collectées de 1961 à 2009 et scindées par régions géographiques et types de forêts. Une autre approche évalue le rôle relatif de manière ascendante (qualité des plantes) et descendante (ennemis naturels) sous différents climats et régimes de gestion forestière. Notre système d'étude est le nuisible défoliateur très répandu Neodiprion sertifer (diprion du pin sylvestre). Sur la base de nos découvertes et des connaissances publiées, nous évoquons (1) si le risque d'invasion d'insecte est touché par le changement climatique ou non et (2) si la gestion forestière peut servir à réduire le risque de dommages causés par les insectes.

## Historical range of variability in temperate mountain spruce forests of Central Europe

Miroslav SVOBODA - Czech University of Life Sciences - Czech Republic

Climate change could significantly alter disturbance regimes in forest ecosystems. In mountain regions of Central and East Europe, scenarios with increased frequency of severe windstorms and droughts, which could trigger large-scale bark beetle outbreaks, are predicted. During the past decade, this region has experienced severe blowdowns and bark beetle outbreaks. Thus, an important question is whether these events are part of the historical range of variability, or whether they are related to climate change and past management practices. In this talk, we review historical evidence regarding the occurrence of severe windstorms and bark beetle outbreaks in the Bohemia Forest (Czech Republic) and the Tatra Mts. (Slovakia), where recently about 20 000 ha of forest was disturbed by windstorms and bark beetle. In addition, we review the few existing studies on the disturbance history and dynamics of spruce forests in the region. Based on historical evidence and published studies, severe stand replacing disturbances, including both windstorms and bark beetle outbreaks, have occurred in the region during the past several centuries and are likely to be part of the historical range of variability in these forests. However, the lack of representative studies makes quantification of the historical disturbance regime difficult. In the second part of the presentation, we also present results of dendroecological study reconstructing disturbance histories from spruce primary forests in Czech Republic and Romania. These studies focused on the disturbance history of an old-growth spruce stands. In these stands, we reconstructed the site's disturbance history using dendroecological methods in a 20 – 40 ha study plots, established to span an elevation gradient. Growth patterns of more then 3000 increment cores were screened for (1) abrupt increases in radial growth indicating mortality of a former canopy tree and (2) rapid early growth rates indicating establishment in a former canopy gap. Our study provides strong evidence that studied stands were historically shaped by a infrequent, moderate- to high-severity natural disturbances. Our methods, however, could not definitively identify the agent(s) of these disturbances. Nevertheless, the recent mid-1990s windstorm and the ensuing spruce bark beetle outbreak may provide an analogue for past disturbance, as the duration and severity of these events could easily explain past patterns of growth response and recruitment in our results. Thus, it seems reasonable to assume the interaction of wind storms and bark beetles seen in the contemporary landscape has occurred historically.

## Étendue historique de variabilité dans les forêts de montagne tempérées d'épicéas d'Europe centrale

Le changement climatique pourrait modifier de manière significative les régimes de perturbations des écosystèmes forestiers. Dans les régions montagneuses d'Europe centrale et de l'Est, les scénarios projetés impliquent une fréquence accrue des orages et des sécheresses sévères, qui pourraient déclencher des invasions de scolytes à grande échelle. Au cours de la dernière décade, la région a subi de sévères chablis et invasions de scolytes. Une question importante se pose : ces événements sont-ils le fruit de l'étendue historique de variabilité ou sont-ils liés au changement climatique et aux pratiques de gestion ? Dans cette discussion, nous analysons les preuves historiques de l'occurrence de graves orages et invasions de scolytes dans la forêt de Bohême (République Tchèque) et les montagnes Tatra (Slovaquie), où 20 000 ha de forêts environ ont récemment été perturbés par des tempêtes et des scolytes. En outre, nous analysons les rares études existantes sur l'historique des perturbations et la dynamique des forêts d'épicéas dans la région. Sur la base des preuves historiques et des études publiées, plusieurs perturbations à l'origine d'un remplacement de peuplement, y compris temêtes violentes et pullulations de scolytes, ont été enregistrées dans la région au cours des siècles derniers et sont susceptibles d'intégrer l'étendue historique de variabilité de ces forêts. Néanmoins, le manque d'études représentatives rend la quantification du régime historique de perturbations difficile. Dans la deuxième partie de la présentation, nous exposons également les résultats d'une étude dendroécologique qui reconstitue les perturbations des forêts primaires d'épicéas en République tchèque et en Roumanie. Ces études se concentrent sur l'historique de perturbation d'un peuplement ancien d'épicéas. Sur ces peuplements, nous avons reconstitué l'historique de perturbations en utilisant des méthodes dendroécologiques sur des parcelles d'étude de 20 - 40 ha, établies pour couvrir un gradient d'élévation. Les variations de croissance de plus de 3 000 carottes de prélèvement ont été analysés pour (1) une augmentation brutale de la croissance radiale indiquant la mortalité d'un arbre du couvert et (2) un taux de croissance précoce rapide indiquant l'établissement dans un ancien creux du couvert. Notre étude prouve que les peuplements étudiés ont été formés historiquement par des perturbations non fréquentes et d'une sévérité modérée à élevée. Nos méthodes n'ont toutefois pas pu identifier les agents de ces perturbations. Néanmoins, les récentes temêtes du milieu des années 1990 et les pullulations de scolytes d'épicéas qui ont suivi peuvent fournir une analogie avec les perturbations passées, car la durée et la gravité de ces événements pourraient facilement expliquer les schémas passés de réponse de croissance et de régéneration dans nos résultats. Il semble donc raisonnable de supposer que l'interaction entre les tempêtes et les pullulations de scolytes constatée dans le paysage contemporain s'est déjà produite dans le passé.

# Drought explains outbreak dynamics and altitudinal range expansion of a destructive bark beetle

Lorenzo MARINI - Italy
Matt P. AYRES - United States
Andrea BATTISTI – Italy
Massimo FACCOLI – Italy

Climate warming and the increased frequency of climatic anomalies such as drought or heat waves are expected to influence both incidence and geographical extent and intensity of bark beetle outbreaks. Amongst scolytids, the European spruce bark beetle Ips typographus (L.) is expected to quickly respond both to the abundance of suitable hosts and to favorable thermal summer conditions. Although I. typographus population dynamics has been described at the northern margin of the host range, little is known on the population dynamics along steep altitudinal gradients at the southern range margin of Norway spruce where drought and heat waves are expected to have a stronger impact. Moreover, to our knowledge no study has empirically investigated the potential expansion of the altitudinal outbreak range of I. typographus in relation to climate change. We characterized the combined effects of climatic factors and density-dependent feedbacks on I. typographus population dynamics, and tested whether current climate change is inducing the expected upward expansion of the altitudinal outbreak range of the species. We analyzed a 16-year time series of I. typographus population dynamics from the European Alps and used a discrete population model and an information theoretic approach to test multiple competing hypotheses. The availability of water-stressed trees appeared as the main driver of population dynamics, i.e. population growth rate was negatively related to summer rainfall through a nonlinear relationship, while temperature-related variables did not play any important role. We found a strong delayed density dependence suggesting an important role of natural enemies. Generally, bark beetle attacks were larger where spruce was planted in sites warmer than those within its historical climatic range. Besides the effect on population growth, increasing drought further induced an upward shift of the altitudinal outbreak range. However, no positive temporal trend in the mean outbreak altitude was found, indicating that single dry years induce temporary altitudinal range expansions which retract downwards once the rainfall regime returns to normal. Climatic changes that cause an increased frequency of summer droughts will render high-altitude forests more susceptible to outbreaks than in the past, which has the potential to produce dramatic changes for Alpine forests.

## La sécheresse comme explication de la dynamique d'invasion et l'expansion de l'étendue altitudinale d'un scolyte destructeur

Le réchauffement climatique et la fréquence accrue d'anomalies climatiques comme la sécheresse ou les vagues de chaleur devraient avoir une influence sur l'incidence, l'étendue géographique et l'intensité des invasions de scolytes. Parmi les scolytidés, le scolyte de l'épicéa européen Ips typographus (L.) devrait répondre rapidement à l'abondance d'hôtes adéquats et aux conditions thermiques estivales favorables. Bien que sa dynamique de population ait été décrite à la lisière Nord de l'essence hôte, les connaissances sont minces sur la dynamique de la population le long des gradients altitudinaux escarpés de la lisière Sud de l'épicéa de Norvège, où les sécheresses et les vagues de chaleur devraient avoir un impact plus important. En outre, à notre connaissance, aucune étude n'a analysé de manière empirique l'expansion potentielle de l'étendue d'invasion altitudinale de I. typographus en lien avec le changement climatique. Nous caractérisons les effets combinés des facteurs climatiques et les retours dépendants de la densité sur la dynamique de populations du I. typographus, et nous testons si le changement climatique entraîne l'expansion prévue vers le haut de l'étendue d'invasion de l'espèce. Nous analysons une série temporelle de 16 ans des dynamiques de populations de I. typographus dans les Alpes européennes et nous utilisons un modèle de population et une méthode théorique distinctes pour éprouver plusieurs hypothèses concurrentes. La disponibilité des arbres contraints sur le plan hydrique est apparue comme le principal facteur de dynamique de population, c'est-à-dire que le taux de croissance des populations est négativement relié aux précipitations estivales par une relation non linéaire, tandis que les variables liées à la température ne jouent pas un rôle important. Nous avons découvert une forte dépendance de densité retardée qui suggère un rôle important des ennemis naturels. En général, les attaques de scolytes sont plus étendues quand l'épicéa est planté sur des sites plus chauds que ceux de son étendue climatique historique. Outre l'effet sur la croissance des populations, l'augmentation des sécheresses entraîne une migration vers le haut de l'étendue d'invasion altitudinale. Néanmoins, aucune tendance temporelle positive dans l'altitude moyenne d'invasion n'a été établie, ce qui indique que les années arides uniques entraînent une expansion temporaire de l'étendue altitudinal qui se rétracte vers la plaine lors du retour à la normale. Les changements climatiques qui provoquent une fréquence accrue des sécheresses estivales rendront les forêts d'altitude élevée plus sensibles aux invasions que par le passé, ce qui génère un potentiel de changements dramatiques dans les forêts alpines.

# MANAGEMENT FOR ADAPTATION 3

**Tuesday 22 May**

**16:15 – 18:00. Scientific Parallel Sessions 5**

# Stand composition and stocking management in Mediterranean Stone pine (P. pinea L.) forests as adaptive measures to climate change

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Mediterranean forests are among the most vulnerable ecosystems under climate change scenarios, thus measures to adapt these forests to the expected reduction in total and seasonal amount of rainfall and warmer temperatures are highly required. The use of thinning to reduce stocking density and the promotion of mixed stands have been proposed as effective measures for adaptation. Thinning is assumed to improve stand water balance and water availability by reducing competition. Meanwhile, as in a mixed stand the optimal spatial distribution of trees and species is assumed, each individual is expected to occupy the most favorable niche for growth. Under these assumptions, trees in low dense mixed stands are expected to show better response in terms of growth than those trees growing in pure high stocking stands, especially in years when drought is a limiting factor. In the present work the previous hypotheses were contrasted for Mediterranean stone pine (Pinus pinea L.) by evaluating the annual growth response to climate conditions of stone pine individuals growing either in pure even-aged or in mixed P. pinea – Juniperus thuriphera - Quercus ilex heterogeneous forests. Pure and mixed stands were selected within the same region (Spanish Northern Plateau), covering a wide range of stocking densities (basal areas from 8 – 20 m2/ha), individual tree sizes and inter- and intraspecific competition status. Annual growth response was assessed using data from radial increment cores covering the 10 year series 1999-2008. During this period average annual rainfall was 450 mm, but annual precipitation was highly variable between years, varying from 245 mm in 2005 to 598 in 2001 Comparisons were carried by fitting linear models including tree size, competition, stocking density, monthly climate data and species composition as explanatory variables for predicting annual tree increment. Our results showed a greater effect of stocking density than species composition, as it is expected in environments where growth is highly dependent on water availability in the soil.

# La composition des peuplements et la gestion des stocks de pins parasols méditerranéens (P. pinea L.) comme mesures adaptatives au changement climatique

Les forêts méditerranéennes comptent parmi les écosystèmes les plus vulnérables au changement climatique, aussi des mesures pour les adapter à la réduction prévue du volume de précipitations total et saisonnier et au réchauffement des températures sont plus que nécessaires. L'utilisation de l'éclaircie pour réduire le stock sur pied et la promotion de peuplements mixtes ont été proposées comme mesures efficaces d'adaptation. L'éclaircie est supposée améliorer l'équilibre et la disponibilité hydriques du peuplement en réduisant la concurrence. Cela dit, un peuplement mixte suppose une distribution spatiale optimale des arbres et des essences, car chaque spécimen est supposé occuper la niche la plus favorable à sa croissance. Ces hypothèses confirment que les arbres des peuplements mixtes à faible densité devraient afficher une meilleure réponse en termes de croissance que ceux des peuplements très denses, particulièrement pour les années pour lesquelles la sécheresse est un facteur contraignant. Cette étude contraste les premières hypothèses pour le pin parasol méditerranéen (Pinus pinea L.) en évaluant la réponse de croissance annuelle aux conditions climatiques de spécimens de pin parasol de forêts équiennes pures et de forêts hétérogènes mixtes P. pinea – Juniperus thuriphera - Quercus ilex. Les peuplements purs et mixtes ont été sélectionnés dans la même région (plateau Nord de l'Espagne) couvrant une large étendue de densités (surface terrière compris entre 8 et 20 $m^2$/ha), de tailles d'arbres individuelles et de statut concurrentiel inter et intraspécifique. La réponse de croissance annuelle a été évaluée en utilisant les données de carottes de prélèvement radial d'une série de 10 ans 1999-2008. Au cours de cette période, les précipitations annuelles ont été en moyenne de 450 mm mais les précipitations annuelles ont grandement varié selon les années, de 245 mm en 2005 à 598 en 2001. Les comparaisons ont été effectuées par intégration de modèles linéaires incluant la taille des arbres, la concurrence, la densité, les données climatiques mensuelles et la composition des essences comme variables explicatives de prévision de l'accroissement annuel des arbres. Nos résultats indiquent un effet plus grand volume sur pied que de la composition des essences, comme attendu dans des environnements où la croissance est très dépendante de la disponibilité hydrique dans le sol.

# Vulnerability assessment of ecosystem services and adaptive management options in Austrian mountain forests under climate change

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Climate change may strongly impact on mountain forests and affect the provision of forest ecosystem services. Beyond timber production, the protection against gravitational natural hazards such as rockfall, snow avalanche, as well as erosion and debris flow, is a key forest ecosystem service in mountainous regions. Additionally, the maintenance of biodiversity and nature conservation goals is important. The quantitative assessment of ecosystem service vulnerability, as well as the design and evaluation of efficient adaptive measures and strategies in mountain forests is a particular challenge, due to manifold involved spatial scales from tree to slope level. In the current contribution, we present a participative vulnerability assessment framework to analyze the current management practices of a large forest holding in the Austrian Alps. Subsequently, suitable adaptive management measures are identified. The assessment is based on simulations with the forest ecosystem model PICUS v1.5, which has been extended significantly for this purpose. Originally designed as a stand level model, PICUS v1.5 is now able to handle slope scale structures and processes. This is essential for the realistic inclusion of mountain forest management practices, as they rely on long distance cable yarding systems. Moreover, the model was extended by a spatial explicit module for the indicator-based assessment of natural hazards, based on the Swiss NaiS system (Frehner et al. 2005). PICUS was used to simulate forest development under current climate and a set of possible future climatic conditions for a period of 100 years. Disturbances from bark beetles and browsing by ungulate game species have been considered in exploring the vulnerability of ecosystem services. Beyond the assessment tools, we present the stakeholder participation and discuss suitability and potential limitations of the approach for adaptation planning.

# Évaluation de la vulnérabilité des services écosystémiques et options de gestion adaptative dans les forêts de montagne autrichiennes dans le contexte du changement climatique

Le changement climatique pourrait avoir un impact élevé sur les forêts de montagne et la fourniture de services écosystémiques forestiers. Outre la production de bois, la protection contre les risques gravitationnels naturels, comme les éboulements, les avalanches ainsi que l'érosion et le flux de débris, est un service écosystémique clé dans les régions montagnardes. En outre, le maintien de la biodiversité et des objectifs de protection de la nature sont essentiels. L'évaluation quantitative de la vulnérabilité des services écosystémiques ainsi que la conception et l'évaluation de mesures et de stratégies adaptatives efficaces dans les forêts de montagne représentent un défi ambitieux, en raison des multiples échelles spatiales impliquées, depuis l'arbre jusqu'à la pente. Cette contribution présente un cadre participatif d'évaluation de la vulnérabilité afin d'analyser les pratiques de gestion actuelles d'une vaste exploitation forestière dans les Alpes autrichiennes. Des mesures de gestion adaptative sont ensuite identifiées. L'évaluation se fonde sur des simulations réalisées à l'aide du modèle d'écosystème forestier PICUS v1.5, élargi de manière significative pour cette étude. Conçu à l'origine pour servir de modèle au niveau du peuplement, PICUS v1.5 est désormais en mesure de traiter les structures et processus d'échelle de pente. Cette donnée est essentielle pour l'inclusion réaliste de pratiques de gestion de forêts de montagne, car elles s'appuient sur des systèmes de débardage à câble longue distance. En outre, le modèle a été élargi par un modèle spatial explicite pour l'évaluation basée sur les indicateurs des risques naturels, fondé sur le système Swiss NaiS (Frehner et al. 2005). PICUS a été utilisé pour simuler le développement forestier dans le contexte climatique actuel et celui des futures conditions climatiques possibles pour une période d'un siècle. Les perturbations dues aux scolytes et l'aboutissement par les ongulés ont été envisagées pour explorer la vulnérabilité des services écosystémiques. Au-delà des outils d'évaluation, nous présentons la participation des parties prenantes et nous discutons de l'adéquation et des limites potentielles de cette méthode pour la planification de l'adaptation.

# Territorial foresight and regional strategies for forest management in the face of climate change - The “Landes de Gascogne 2050” case study

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The aim of this communication, based on a territorial foresight study, is to assess how maritime pine forest and its forest-based sector may adapt to climate change in southwestern France. This study was launched after the storm Klaus by the Regional Council of Aquitaine and the French Institute for Agricultural Research (INRA). Contrasting scenarios regarding territorial futures of the “Landes de Gascogne” (LG) in 2050 are developed to support decision making processes. They integrate climatic risks through the issues of the resilience of forest ecosystems and their socio-economic uses. How can this territorial foresight study help to understand the adaptation of southwestern France forest and its forest-based sector to climate change? At first, scenarios offer an interesting framework for taking into account current uncertainties on climate change. Since they put forward a plurality of futures and highlight actions which would be necessary to reach them, these scenarios are useful for anticipating possible ruptures (Mermet and Farcy, 2011). Moreover, scenario-building is a collective analysis; the scenarios were elaborated by a multi-disciplinary and multi-institutional expert panel. This stakeholder's approach integrates social values and thus agrees with the new paradigm governing forest practices (Wang and Wilson, 2006). Secondly, our foresight study offers an original approach regarding climate change adaptation strategies by questioning territorial insertion of the forest. The LG area, bounded by metropolitan zones and by the coastline, is subject to a substantial population growth, a change in economic activities and a diversification of its social uses. Moreover, the forest-based sector, which was until now strongly linked to wood exploitation and was a local source of employment, is being reorganized. Studying the way innovations in forest management and forest-based sector will occur in different territorial configurations helps to consider the effects of specific territorial arrangements involving non-forest actors on forest adaptation to climate change. We will first explain the context of the foresight study and the main issues it had to consider. Then we will present the four scenarios built by the expert panel and assess their vulnerability to climate change. This will lead us to assume that the resilience of the forest ecosystems and their socio-economic valorization require better articulation between forest-based and territorial policies. We will particularly consider the role of socio-technical agencies (Callon et al., 2001) in forest management and stress the importance of interfaces between forest innovation, regional strategies and territorial actors.

**Prospective territoriale et stratégies régionales pour la gestion forestière dans le contexte du changement climatique. Étude de cas « Landes de Gascogne 2050 »**

L'objectif de cette communication, fondée sur une prospective territoriale, est d'évaluer comment le pin maritime et son secteur forestier pourraient s'adapter au changement climatique dans le sud-ouest de la France. Cette étude a été lancée après la tempête Klaus par le Conseil régional d'Aquitaine et l'INRA. Des scénarios contrastés en matière d'avenir territorial des « Landes de Gascogne » (LG) en 2050 sont développés pour contribuer aux processus de prise de décision. Ils intègrent les risques climatiques en questionnant la résistance des écosystèmes forestiers et leurs utilisations socioéconomiques. Comment cette prospective prédictive territoriale peut-elle contribuer à comprendre l'adaptation au changement climatique de la forêt du sud-ouest de la France et de son secteur forestier ? Premièrement, les scénarios offrent un cadre intéressant pour prendre en compte les incertitudes actuelles en matière de changement climatique. Puisqu'ils mettent en avant plusieurs schémas possibles et soulignent les actions nécessaires pour les atteindre, ces scénarios sont utiles pour anticiper les ruptures possibles (Mermet and Farcy, 2011). En outre, l'élaboration d'un scénario est une analyse collective, élaborée par un panel d'experts pluridisciplinaire et pluri institutionnel. Cette approche aux parties prenantes intègre les valeurs sociales et concorde ainsi avec le nouveau paradigme qui gouverne les pratiques forestières (Wang and Wilson, 2006). Deuxièmement, notre étude prédictive offre une approche originale en matière de stratégies d'adaptation au changement climatique en questionnant l'intégration territoriale des forêts. Les LG, délimitées par des zones métropolitaines et la ligne côtière, sont exposées à une croissance importante de la population, à une modification des activités économiques et à une diversification de leur utilisation sociale. En outre, le secteur forestier, jusqu'alors fortement lié à l'exploitation du bois et source d'emploi localement, est en cours de réorganisation. Étudier la manière dont les innovations dans la gestion forestière et le secteur forestier vont se déployer sur différentes configurations territoriales contribue à envisager les effets de dispositions territoriales spécifiques impliquant des acteurs non forestiers sur l'adaptation de la forêt au changement climatique. Nous expliquons d'abord le contexte de l'étude prédictive et les principales questions prises en compte. Nous présentons ensuite les quatre scénarios élaborés par le panel d'experts et nous évaluons leur vulnérabilité au changement climatique. Cela nous conduit à supposer que la résistance des écosystèmes forestiers et leur valorisation socioéconomique requièrent une meilleure articulation entre les politiques forestières et territoriales. Nous étudions plus particulièrement le rôle des agences sociotechniques (Callon et al., 2001) dans la gestion forestière et soulignons l'importance des interfaces entre l'innovation forestière, les stratégies régionales et les acteurs territoriaux.

# Climate change impact and adaptation in the managed canadian boreal forest: a review of current knowledge

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The managed boreal forest of Canada is both exposed and sensitive to climate variability and change. It is also a source of environmental and economic goods and services to local and national populations. Climate change adaptation of the managed forest and of the forest sector is therefore important for Canada, and issues related to this process are reviewed in this presentation. Current signs of climate change are being observed within the managed forest, including increased extreme rainfall events, shorter winter road seasons, and range expansion of some animal species. In eastern Canada, parts of the boreal forest that were too cold for spruce budworm, a major forest pest, are now being heavily infested by the insect. The frequency of forest fires is expected to increase in the future, while increases in growth are less certain on account of potential water limitations. Climate change also opens the possibility to more extreme insect epidemics and to a greater susceptibility to invasive pests. Such fluctuations are not unprecedented. Holocene-level records reveal that past climate fluctuations have altered the relative importance of tree species, but not the overall tree species pool of the boreal forest. Based on this evidence, we propose that the managed boreal forest of Canada is both exposed and sensitive, but not vulnerable in itself to climate change. On the other hand, forest-based activities that depend on very local set of forest properties may be highly vulnerable to climate change. Examples include species-specific timber needs by industry, conservation area networks, and traditional knowledge and activities by Canada's Aboriginal people. These effects cascade down to local forest-based communities whose economic or social viability is dependant on forest-based activities. Forest-based communities are also increasingly vulnerable to wildfires. Adaptation measures are currently being autonomously implemented by forest industry to cope with the most immediate impacts of climate change on forest operations. Future adaptation measures may include changes in the planning and regulation framework of forest management and changes in wildlife management regulations to reduce impacts and capture opportunities brought about climate change. Provincial and federal governments are working to provide information to resource and community managers in order to facilitate the identification and implementation of adaptation measures and to identify opportunities.

## Impact et adaptation au changement climatique dans les forêts gérées boréales au Canada : analyse des connaissances actuelles

La forêt boréale gérée du Canada est la fois exposée et sensible à la variabilité et au changement climatiques. Elle est également source de biens et de services environnementaux et économiques pour les populations locales et nationales. L'adaptation au changement climatique de la forêt gérée et du secteur forestier est donc importante pour le pays, et cette présentation analyse les questions liées à ce processus. Les signes actuels du changement climatique sont observés dans les forêts gérées, y compris une hausse des événements de précipitations extrêmes, des saisons hivernales plus courtes et une expansion de l'étendue de certaines espèces animales. Dans l'est du Canada, certaines régions de la forêt boréale auparavant trop froides pour la tordeuse de l'épicéa, un nuisible forestier majeur, sont désormais gravement infestées par cet insecte. La fréquence des feux de forêt devrait augmenter dans l'avenir, tandis que les augmentations de croissance sont moins certaines en raison de limitations hydriques potentielles. Le changement climatique ouvre également la possibilité d'invasions d'insectes plus extrêmes et d'une plus grande sensibilité aux invasions de nuisibles. De telles fluctuations ne sont pas sans précédent. Les enregistrements au niveau de l'holocène révèlent que des fluctuations climatiques par le passé ont modifié l'importance de certaines essences, mais pas le bassin d'ensemble des essences de la forêt boréale. Sur la base de ce constat, nous suggérons que la forêt gérée boréale du Canada est exposée et sensible, mais pas vulnérable en soi au changement climatique. D'un autre côté, les activités forestières qui dépendent d'un panel très local de propriétés forestières peuvent être extrêmement vulnérables au changement climatique. Par exemple, les besoins spécifiques en essence de bois d'œuvre du secteur, les réseaux d'aire de conservation et les activités et connaissances traditionnelles des peuples aborigènes du Canada. Ces effets se transmettent en cascade aux communautés forestières dont la viabilité socioéconomique est dépendante des activités forestières. Les communautés forestières sont également toujours plus vulnérables aux feux de forêt. Les mesures d'adaptation sont actuellement mises en œuvre de manière autonome par le secteur forestier pour faire face aux impacts les plus immédiats du changement climatique sur les opérations forestières. Les futures mesures d'adaptation pourraient inclure des changements dans le cadre de planification et de réglementation de la gestion forestière et des modifications aux réglementations de gestion de la vie sauvage afin de réduire les impacts et de saisir les opportunités suscitées par le changement climatique. Les gouvernements fédéraux et provinciaux travaillent à fournir des informations aux responsables des ressources et des communautés afin de faciliter l'identification et la mise en œuvre de mesures d'adaptation et d'identifier des opportunités.

## Tree breeding as a tool to minimize possible adverse effects of climate changes on forest trees

Aris JANSONS - LSFRI Silava - Latvia

Adaptation to changing climatic conditions is crucial to ensure survival and vitality of forest stands. Data about adaptive traits for the study were gathered in four open-pollinated progeny trials of Scots pine, Norway spruce and silver birch in central part of Latvia at the age of 5 to 8 years. Results reveal, that needle cast has a significant negative influence on survival and cumulative negative influence on height growth of young Scots pines (family mean correlation between needle cast damage grade and height increment of current year r=-0.30, increment of next year r=-0.53). Significant differences exist between families in needle cast damage grade, ranging from almost not affected to 80% of one year old needles affected. Average proportion of trees with lammas growth, related to increased length of vegetation period, reaches 8% in young Norway spruce plantation. Significant differences exists between families and most affected of them have on average 36% of trees with lamas growth, that will adversely affect the future quality of trees and can cause notable frost damages. Provenances and families was found to be a significant factor, determining tree height, branch diameter and angle in young silver birch plantation. The distance between them, related to shift in climatic conditions, within Latvia (2 latitudes) does not explains the differences in tree height growth. Tree breeding provides opportunity for significant improvement of productivity as well as traits important for adaptation at current and predicted future climatic conditions. Selection for desired trait important for adaptation needs to be carried out in the trials or controlled conditions, but does not necessarily involves tradeoffs for growth traits.
Acknowledgements: ECHOES; ESF grant Importance of Genetic Factors in Formation of Forest Stands with High Adaptability and Qualitative Wood Properties

## La génétique forestière comme outil de minimisation des conséquences défavorables possibles du changement climatique sur les arbres forestiers

L'adaptation à l'évolution des conditions climatiques est essentielle pour assurer la survie et la vitalité des peuplements forestiers. Les données de cette étude sur les caractéristiques adaptatives ont été collectées auprès de quatre tests de descendance en pollinisation ouverte sur le pin sylvestre, l'épicéa commun et le bouleau blanc situés dans le centre de la Lettonie et âgés de 5 à 8 ans. Les résultats indiquent que la chute des aiguilles a une influence négative significative sur la survie et une influence négative cumulative sur la croissance en hauteur des jeunes pins d'Écosse (corrélation moyenne familiale entre le degré de chute des aiguilles et la croissance en hauteur de l'année en cours r=-0,30 ; croissance de l'année suivante r=-0,53). Des différences significatives existent entre les familles en matière de degré de chute des aiguilles, qui oscillent entre une quasi absence et 80 % des aiguilles âgées de un an touchées. La proportion moyenne d'arbres présentant une pousse d'été, liée à la durée accrue de la période de végétation, atteint 8 % chez les jeunes épicéas de Norvège. Des différences significatives existent entre les familles et les plus touchées présentent en moyenne 36 % d'arbres avec une pousse d'été, qui aura un impact négatif sur la future qualité des arbres et peut provoquer de lourds dommages liés au gel. Les provenances et les familles sont également un facteur significatif, elles déterminent la hauteur de l'arbre, le diamètre et l'angle des branches chez les jeunes bouleaux blancs. La distance qui les sépare, associée à la modification des conditions climatiques, au sein de la Lettonie (2 latitudes), n'explique pas les différences de croissance en hauteur des arbres. La génétique forestière fournit l'opportunité d'une amélioration significative de la productivité ainsi que des caractéristiques importantes pour l'adaptation aux conditions climatiques actuelles et futures. La sélection des caractéristiques souhaitées doit se faire dans des tests ou sous conditions contrôlées, mais n'implique pas nécessairement des échanges de caractéristiques de croissance.

Remerciements : ECHOES ; subvention ESF Importance des facteurs génétiques dans la formation des peuplements forestiers présentant une capacité élevée d'adaptation et des propriétés quantitatives du bois/Importance of Genetic Factors in Formation of Forest Stands with High Adaptability and Qualitative Wood Properties

# Preparedness to climate change in European forestry based on COST ECHOES database on adaptive measures

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Within the COST Action ECHOES, a database of the climate change adaptation measures in forestry was compiled. The database was developed on the basis of an earlier survey commissioned by the DG Agri, complemented by the COST ECHOES country representatives with information about the location, forest type and tree species to which the measures refer, the climate change impacts addressed, as well as the anticipated effectiveness, possible trade-offs and their status of implementation (ongoing/planned/idea). Additional measures were also added by the country representatives. By August 2011, the database included a total of 444 adaptation measures from 19 countries. In this study, the database was scrutinized to assess the preparedness to climate change in different bioclimatic regions. The ECHOES data indicate that the need for adaptation strategies to respond to climate change is recognized all over Europe. The target of reported measures – reducing climate change related impacts or improving adaptive capacity of the forests varies across forest types in different bioclimatic regions in Europe. A closer look at the status of the measures reveals that in all regions forests are already managed to be more tolerant to future conditions and extreme events; i.e. species and provenances that are more tolerant to future conditions are used in regeneration, and tree species diversity is taken into account in both the regeneration and thinning and tending phase to enhance the adaptive capacity of forests. In the Mediterranean region investments in fire prevention policies (e.g., increasing private and public awareness, education campaigns of forest managers) and improving infrastructure for fire detection, control and suppression have been initiated. However, there are also many country-specific measures which are still in the planning phase – e.g. although there is a growing theoretical awareness about reducing the biotic and abiotic damage, there is still a high developmental need for monitoring and early warning systems.

# État de préparation au changement climatique de la sylviculture européenne fondée sur la base de données des mesures adaptatives COST ECHOES

Au sein de l'Action COST ECHOES, une base de données de mesures d'adaptation au changement climatique a été collectée. Elle a été développée sur la base d'une précédente enquête commandée par le DG Agri, complétée par les représentants des pays COST ECHOES avec des informations sur l'emplacement, le type de forêt et les essences d'arbres auxquelles les mesures font référence, les impacts du changement climatique pris en compte ainsi que l'efficacité anticipée, les échanges possibles et leur statut de mise en œuvre (en cours, planifiée, idée). Des mesures complémentaires ont également été ajoutées par les représentants des pays. En août 2011, la base contenait 444 mesures d'adaptation au total pour 19 pays. Cette étude analyse la base de données pour évaluer l'état de préparation au changement climatique dans différentes régions bioclimatiques. Les données ECHOES confirment que le besoin de stratégies d'adaptation pour réagir aux impacts du changement climatique est reconnu partout en Europe. L'objectif des mesures rapportées – réduction des impacts liés au changement climatique ou amélioration de la capacité adaptative des forêts – dépend des types de forêts et des régions bioclimatiques. Un aperçu plus précis du statut des mesures indique que, dans toutes les régions, les forêts sont déjà gérées pour gagner en tolérance aux futures conditions et aux événements extrêmes ; c'est-à-dire que les essences et les provenances plus tolérantes aux futures conditions sont utilisées pour la régénération, et que la diversité des essences est prise en compte pour les phases de régénération et d'éclaircie et de culture afin de renforcer la capacité adaptative des forêts. Dans la région méditerranéenne, les investissements en faveur des politiques de lutte contre les incendies (par ex. sensibilisation privée et publique, campagnes d'éducation des gestionnaires forestiers) et l'amélioration des infrastructures de détection, de contrôle et de lutte contre les incendies ont été mis en place. Néanmoins, de nombreuses mesures spécifiques aux pays sont encore en phase de planification – par ex., bien qu'il existe une prise de conscience théorique croissante sur la réduction des dommages biotiques et abiotiques, un besoin fort de développement subsiste pour le contrôle et les systèmes d'alerte précoces.

# SOCIO ECONOMIC ASPECTS AND KNOWLEDGE MANAGEMENT

**Tuesday 22 May**

**16:15 – 18:00. Scientific Parallel Sessions 5**

## A first national assessment of climate change risks for forestry in the UK

Prof Andy MOFFAT - Forest Research - United Kingdom
Dr James MORISON - Forest Research - United Kingdom
Dr Bruce NICOLL - Forest Research - United Kingdom

The UK Climate Change Act (2008) provided the world's first long-term legally binding national framework to reduce greenhouse gas emissions. The Act also created a framework for developing the UK's ability to adapt to climate change, including a UK-wide Climate Change Risk Assessment (CCRA) that must take place every five years, and a national adaptation programme for England. The first formal CCRA has been prepared and was published in January 2012. It contains a detailed assessment of the risks to eleven major sectors (transport, water, agriculture, business, health etc.), one of which is forestry. This presentation describes the process of producing the forestry report and its main findings. The methodology for identifying key risks and prioritising them for subsequent analysis is summarised and the main risks briefly discussed. Methods for building 'risk metrics' and 'consequence response functions' for assessing likely change, and their use with projections of climate change are outlined. Other parts of the CCRA, including a social vulnerability assessment and analysis of sector adaptive capacity are described. It is concluded that in Britain, the main likely effects of climate change will be experienced through the effects of increasing damage by insect pests and microbial pathogens, and through the impact on tree and forest productivity by changes to temperature, rainfall, atmospheric $CO_2$ concentration and length of the growing season. Tree species suitability is therefore predicted to change substantially, in the medium and long-term. Adaptive management practices will subtly change the character and ecology of woodlands, as new native and non-native species are introduced to different parts of the country. Other important risks include loss to forest biodiversity and amenity, windthrow, landslips and forest fires. In the absence of other factors, modelling suggests that productivity will decrease significantly in England, particularly in the drier south and east, but increase for several commercial species in Scotland. In Wales, some species are predicted to increase in productivity whilst others may decrease. The degree of these changes has been quantified on the basis of modelled results and has been used to quantify the economic consequences of predicted change. Further work will provide an analysis of the costs and benefits of adaptation measures designed to mitigate the key risks from climate change identified in the CCRA study. In addition, outputs from the CCRA process will be incorporated into devolved country forestry adaptation plans.

# Une première évaluation nationale des risques liés au changement climatique pour la sylviculture au Royaume-Uni

Le UK Climate Change Act (2008) a fourni le premier cadre juridique national à long terme dans le monde destiné à réduire les émissions de gaz à effet de serre. Cette Loi a également créé un cadre de développement de la capacité du Royaume-Uni à s'adapter au changement climatique, intégrant une évaluation des risques du changement climatique à l'échelle du Royaume qui doit se dérouler tous les cinq ans et un programme national d'adaptation pour l'Angleterre. La première évaluation formelle a été préparée et publiée en janvier 2012. Elle propose une évaluation détaillée des risques sur onze secteurs principaux (transport, eau, agriculture, entreprises, santé, etc.), dont la sylviculture. Cette présentation décrit les procédures de production du rapport forestier et ses principales conclusions. La méthodologie d'identification des risques principaux et de leur hiérarchisation pour analyse future est résumée et les principaux risques brièvement évoqués. Les méthodes d'élaboration des « métriques du risque » et des « fonctions de réponse aux conséquences » pour l'évaluation sont susceptibles d'évoluer, et leur utilisation avec les projections de changement climatique est mise en avant. D'autres aspects de l'évaluation, y compris une évaluation de la vulnérabilité sociale et une analyse de la capacité adaptative du secteur, sont décrits. Les conclusions affirment qu'en Grande-Bretagne, les principaux effets probables du changement climatique seront une augmentation des dommages causés par les insectes nuisibles et les pathogènes microbiens, et ceux liés à l'impact sur la productivité des arbres et des forêts des modifications des températures, des précipitations, de la concentration en $CO_2$ dans l'atmosphère et de la durée de la saison de croissance. L'adaptation des essences d'arbres devrait par conséquent évoluer en profondeur à moyen et long terme. Les pratiques de gestion adaptative modifieront de manière subtile le caractère et l'écologie des espaces boisés, alors que des essences natives et non natives sont introduites dans différentes régions du pays. Les autres risques importants incluent la perte de biodiversité et d'aménités forestières, les chablis, les glissements de terrain et les feux de forêt. En l'absence d'autres facteurs, la modélisation suggère que la productivité va baisser de manière significative en Angleterre, particulièrement dans le Sud et l'Est, plus arides, mais aussi qu'elle va augmenter pour plusieurs essences commerciales en Écosse. Au Pays de Galles, certaines essences devraient améliorer leur productivité et d'autres la réduire. Le degré de ces changements a été quantifié sur la base de résultats modélisés et a été utilisé pour quantifier les conséquences économiques du changement annoncé. Des travaux complémentaires fournissent une analyse des coûts et des bénéfices des mesures d'adaptation conçues pour réduire les principaux risques du changement climatique. En outre, les conclusions du processus seront intégrées dans des plans d'adaptation dédiés.

# Assessing Experts' Opinion on Challenges and Opportunities of Tackling Deforestation in the tropics: a Q- Method Application

Maria NIJNIK - The James Hutton Institute - United Kingdom
Albert NIJNIK - Environmental Network Ltd – Ukraine
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Various dimensions of tackling deforestation to mitigate climate change, including the effectiveness and feasibility of policy measures, as they are perceived by experts are analysed in this paper. The Q-method is used (i) to identify and explain existing attitudes towards REDD/REDD+, with the primary focus on Peru, Cameroon and Indonesia, and (ii) to provide some insights into the success and failures of policy interventions to alleviate deforestation, with further consideration of opportunities and challenges to implement sustainable policy measures on the ground. The conclusion is that there is an interplay of the proximate and underlying causes of deforestation, and that its drivers operate at different scales and are not easy to handle. The results indicate that the potential of REDD/REDD+ projects is shaped not only by international climate change and forestry policies and instruments but to a large extend by national and regional policies and various local cultural values that affect susceptibility to develop forest-based activities on the level of indigenous communities, large and small businesses and on the acceptability of these projects by people on the ground. It has been the case that land use decisions are shaped less by market signals and more by international arrangements on the national, regional and local levels of governance and by public policy initiatives towards sustainable forestry in combination with climate change mitigation. The potential to tackle climate change through combating of deforestation not only positively shape climate mitigation policy with respect to forestry but, if successful, could provide additional opportunities to developing countries of economic, social and environmental nature (e.g. biodiversity conservation, or poverty alleviation). Overall, the results have provided (i) some useful information about the opportunities and challenges of tackling deforestation which might have important implications for the implementation and acceptability of REDD-type intervention measures and (ii) some new insights into social choices to support decision-making.

## Évaluer l’avis des experts sur les défis et les opportunités de la lutte contre la déforestation dans les tropiques : application de la méthode Q

Cette présentation analyse diverses dimensions de lutte contre la déforestation pour réduire le changement climatique, y compris l’efficacité et la faisabilité des mesures politiques, telles qu’elles sont perçues par les experts. La méthode Q est utilisée pour (i) identifier et expliquer les attitudes existantes à l’égard de REDD/REDD+, en se concentrant principalement sur le Pérou, le Cameroun et l’Indonésie et (ii) fournir des perspectives sur les réussites et les échecs des interventions politiques pour atténuer la déforestation, en insistant sur les opportunités et les défis liés à la mise en œuvre de mesures politiques durables sur le terrain. Une interaction existe entre les causes immédiates et sous-jacentes de la déforestation, et ses facteurs opèrent à des échelles différentes et ne sont pas faciles à appréhender. Les résultats indiquent que le potentiel des projets REDD/REDD+ est dépendant non seulement des politiques et des instruments internationaux en matière de changement climatique et de sylviculture, mais aussi en grande partie des politiques nationales et régionales et des différentes valeurs culturelles locales, qui ont un impact sur la susceptibilité de développer des activités forestières au niveau des communautés indigènes, des petites et grandes entreprises, mais aussi sur l’acceptation de ces projets par les personnes sur le terrain. Les décisions en matière d’utilisation des terres sont définies moins par les signaux du marché que par les arrangements internationaux à l’échelle locale, régionale et nationale de gouvernance et par les initiatives de politique publique en faveur d’une sylviculture durable associée à la réduction du changement climatique. Le potentiel de réduction du changement climatique par la lutte contre la déforestation ne modèle pas seulement de manière positive les politiques en matière de sylviculture mais, en cas de réussite, fournit également des opportunités de développer les pays sur le plan économique, social et environnemental (par ex. protection de la biodiversité ou réduction de la pauvreté). Dans l’ensemble, les résultats proposent (i) des informations utiles sur les opportunités et les défis liés à la lutte contre la déforestation qui pourraient avoir des implications importantes sur la mise en œuvre et l’acceptation des mesures d’intervention de type REDD et (ii) de nouvelles perspectives sur les choix sociaux pour éclairer la prise de décision.

## Adaptation, mitigation and ecosystem services - Challenges to sustainable forest management and resarch needs

Dr Jean-François DHOTE - ONF - France

We discuss climate change and sustainable management with regard to adaptation, mitigation and ecosystem services. What specific challenges do forest managers face ? What questions emerge when trying to define adaptive silviculture or management planning ? What research topics should receive special attention ? What new tools are needed to support decision-making ? Challenges : are management options for adaptation & mitigation convergent ? If not, how to choose or combine different management options in space ? How to decide under uncertainty : give examples of no-regret options, reversible options, dead-ends ? How to be prepared to surprises (favourable or not) ? Do we need more regulations, flexibility, training, innovation to secure sustainable management ? Diversity of drivers to take into account in decision-making : climate (long trends, decadal cycles, fluctuations), pollution (future N-deposition ?), land-use change (here and abroad), timber markets (emerging competition between timber uses, eg solid wood, fibres, chemicals, energy), silvicultural and harvesting systems, social demands (convergence and/or conflicts between competing uses), ecology (gradual shifts and disturbances, role of genetic diversity, conservation policies). Forest managers increasingly need improved modelling, simulation and projection tools, and corresponding experimental platforms : at different scales (stand, forest, region), horizons (2030, 2100, beyond ?), for various ecosystem services (production, carbon, water, biodiversity, protection against hazards, recreation). The talk concludes with a list of R&D issues and expected products : guidelines for species choice (incl. non-native), genetic material in plantations, assisted migration and species mixtures ; flexible and general site assessment methods ; silvicultural options to strengthen drought resistance ; soil management ; tending and harvesting machinery ; integrated management models for decision-making ; optimality and viability domains for silviculture under combined risks (drought, storms, fire, pests...) ; compatibility between social demands (eg biodiversity, fire or disease prevention, visitor safety, game/forest management) ; prospective on timber markets, wood quality, demand/supply, payment of ecosystem services ; methodology for adaptive management ; biodiversity conservation policies in the light of climate change

## Adaptation, atténuation et services écosystémiques – Défis pour la gestion forestière durable et besoins de la recherche

Nous discutons du changement climatique et de la gestion durable en matière d'adaptation, d'atténuation et de services écosystémiques. Quels défis spécifiques attendent les gestionnaires forestiers ? Quelles questions émergent quand on essaie de définir une sylviculture adaptative ou une planification de la gestion ? Quels sont les sujets de recherche qui doivent bénéficier d'une attention spécifique ? Quels sont les nouveaux outils nécessaires pour éclairer la prise de décision ? Défis : les options de gestion pour l'adaptation et la atténuation convergent-elles ? Dans le cas contraire, comment choisir ou associer différentes options de gestion dans l'espace ? Comment départager les incertitudes : donner des exemples d'options sans possibilité de retour, d'options réversibles, de voies sans issue ? Comment se préparer aux surprises (positives ou non) ? Avons-nous besoin de plus de réglementations, de flexibilité, de formation, d'innovation pour sécuriser une gestion durable ? Diversité des facteurs à prendre en compte dans la prise de décision : climat (tendances à long terme, cycles décadaux, fluctuations), pollution (futur dépôt d'azote ?), changements d'utilisation des terres (ici et à l'étranger), marchés du bois d'œuvre (concurrence émergente entre les utilisations du bois d'œuvre, par ex. bois solide, fibres, chimique, énergie), systèmes de sylviculture et de récolte, demandes sociales (convergence et/ou conflits entre les utilisations concurrentielles), écologie (mutations progressives et perturbations, rôle de la diversité génétique, politiques de conservation). Les gestionnaires forestiers ont toujours plus besoin d'outils améliorés de modélisation, de simulation et de projection, et de plates-formes expérimentales correspondantes : à des échelles différentes (peuplement, forêt, région), des horizons variés (2030, 2100, au-delà ?), pour des services écosystémiques divers (production, carbone, eau, biodiversité, protection contre les risques, loisirs). Cette discussion s'achève par une liste de questions R&D et de produits attendus : recommandations pour le choix des essences (y compris non natives), supports génétiques des plantations, migration assistée et mélange d'essences, méthodes d'évaluation des sites flexibles et générales, options sylvicoles pour renforcer la résistance à la sécheresse, gestion des sols, méchanisation, éclaircies de récoltes, modèles de gestion intégrée pour la prise de décision, domaines d'optimalité et de viabilité pour la sylviculture dans des risques combinés (sécheresses, tempêtes, feux, nuisibles, etc.), compatibilité entre les demandes sociales (par ex. biodiversité, prévention des incendies ou des maladies, sécurité des visiteurs, gestion forestière/de la faune), perspectives sur le marché du bois d'œuvre, qualité du bois, offre/demande, règlement des services écosystémiques, méthodologie de gestion adaptative, politiques de protection de la biodiversité à l'aune du changement climatique.

# Forest owner motivations and attitudes towards land-use change for bio-energy production in Europe

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European leaders have agreed to increase the share of renewable energy as a strategy to mitigate climate change. Recent reviews suggest bio-energy to be used more extensively in the future as one important means of reaching the goal. As the demand for bio-energy increases, the market price and competition for land could increase. Land that currently is used for food and fiber production could be used for the production of bio-energy feedstock, and could lead to land areas important for the conservation of biodiversity being used for production. In the EU private forest owners own 60% of the forest acreage. There are two main arguments for a forest owner to produce biomass for energy use. First, it could present an opportunity for the land-owner to contribute to climate change mitigation. Secondly, the change could present a business opportunity. However, the motivation for meeting any of these two goals have to compete with all other goals the forest owner may have. But for change of land-use to take place, land-owners need to have a positive attitude towards the change. We used survey data collected from private individual forest-owners in Portugal, Germany and Sweden to examine their attitudes and motivations to use the land for production of biomass for energy use. Preliminary results indicate that a. The willingness to change land-use was low among the respondents from all three countries. b. Even if German forest owners believed most strongly in a strong and persistent demand for forest based bio-energy feedstock, at most half of the German forest owners had a positive attitude towards expanding their forest acreage for forest bio-energy purposes by converting land used for other purposes into forest land. c. A lower proportion of forest owners in Germany and Sweden, but not in Portugal, had positive attitudes towards converting agricultural land into forest land compared to converting pasture or land used for other purposes than agriculture into forest land. d. German forest owners were less inclined than Swedish and Portuguese forest owners to convert forest that they currently are tending for timber production into forest for bio-energy production, even if this would provide higher financial return. e. The attitude towards converting forest land into land for production of bio-energy crops was most positive in Portugal and the least positive in Germany.

## Motivations et attitudes des propriétaires forestiers à l’égard des modifications de l’utilisation des terres pour la production bioénergétique en Europe

Pour réduire le changement climatique, les dirigeants européens ont décidé d’augmenter la part d’énergies renouvelables. Les analyses récentes suggèrent une utilisation plus extensive des bioénergies à l’avenir pour atteindre l’objectif. La demande pour les bioénergies augmente, le prix et la concurrence pour les terrains pourraient donc augmenter eux aussi. Les terres utilisées à l’heure actuelle pour l’alimentaire et les fibres textiles pourraient être consacrées aux bioénergies ; des zones importantes pour la protection de la biodiversité pourraient ainsi être dédiées à la production. Au sein de l’Union européenne, les propriétaires forestiers privés détiennent 60 % de la superficie forestière totale. Deux arguments peuvent les amener à produire de la biomasse pour une utilisation énergétique. Premièrement, cette option peut présenter une opportunité de contribuer à la réduction du changement climatique. Deuxièmement, l’opportunité peut être commerciale. Néanmoins, la motivation pour atteindre l’un ou l’autre de ces deux objectifs entre en concurrence avec les autres objectifs éventuels du propriétaire forestier. Mais pour que l’utilisation des terrains soit modifiée, les propriétaires doivent adopter une attitude positive vis-à-vis du changement. Nous nous sommes appuyés sur des données collectées auprès de propriétaires forestiers privés au Portugal, en Allemagne et en Suède pour analyser leur attitude et leurs motivations à l’égard d’une utilisation de leurs terrains pour la production de biomasse à des fins énergétiques. Les résultats préliminaires indiquent que a. la volonté de modifier l’utilisation des terrains est faible chez les répondants des trois pays b. même si les propriétaires allemands sont plus fortement convaincus d’une demande constante et solide pour une matière bioénergétique forestière, au maximum la moitié d’entre eux nourrissent une attitude positive à l’égard d’une expansion de leur superficie forestière dédiée aux utilisations bioénergétiques en convertissant les terres utilisées pour d’autres objectifs c. une plus faible proportion de propriétaires forestiers en Allemagne et en Suède, mais pas au Portugal, nourrissent une attitude positive à l’égard d’une conversion des terres agricoles en terres forestières par rapport à la conversion en terres forestières des pâturages ou des terrains utilisés à d’autres fins que l’agriculture. d. les propriétaires forestiers allemands sont moins enclins que les Suédois et les Portugais à convertir les forêts qu’ils cultivent déjà pour la production de bois d’œuvre pour la production de bois destiné à la bioénergie, même si cela assurerait de meilleurs retours financiers, l’attitude vis-à-vis de la conversion de terres forestières en terres destinées à la production de cultures bioénergétiques est reçue la plus positivement au Portugal et la moins positivement en Allemagne.

# A web-based tool for participatory vulnerability assessment of forest ecosystem services

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Climate change may strongly impact forests and affect the provision of forest ecosystem services (ES). In addition, at operational level the assessment, planning and implementation of adaptive measures in forest management requires coordination among various stakeholders. The consideration of ES such as timber production, protection against natural hazards such as snow avalanches, rockfall and debris flow, nature conservation values and landscape amenities and the trade-offs among them within the frame of multi-functional forestry must be performed at local to regional scales. For successful applications a proper and transparent integration of stakeholder views and values is of paramount importance. To support such assessment and planning processes a web-based assessment tool has been developed. In this contribution we present the conceptual foundation of the decision support tool, its implementation and demonstrate the tool by means of case study data from the MOTIVE project. The tool can either be used by individual decision makers or in a group setting where stakeholders participate in a workshop environment. Employing a web-based user interface, the user is guided through the assessment procedure which is based on the major decision making phases: (1) problem structuring (case selection, definition of objectives and related indicator sets), (2) preference elicitation (importance of indicators and identification of tolerance thresholds regarding climate change impacts), and (3) assessment. Several cycles of this procedure may be performed to test the effect of alternative preference settings and management practices on the residual vulnerability. The indicators are used to assess the performance of forest management as related to the demanded ecosystem services. Performance data of management trajectories for any given forest type can be provided by prior ecosystem simulations or qualitative expert judgments stored in a data base. The indicators are then aggregated with regard to a two-dimensional vulnerability surface sensu Luers (2005) characterizing sensitivity as well as state/threshold relationships of ES towards climate change. The resulting position of a specific management scheme and its movement on the vulnerability surface along a temporal trajectory is a suitable communication means also to non-experts and laymen among stakeholders. Benefits as well as potential limitations of the current tool as well as possible future enhancements are discussed.

## Un outil Web pour une évaluation participative de la vulnérabilité des services écosystémiques forestiers

Le changement climatique pourrait avoir un impact important sur les forêts et les services écosystémiques forestiers. En outre, à l'échelle opérationnelle, l'évaluation, la planification et la mise en œuvre de mesures adaptatives de gestion forestière requièrent une coordination entre les différentes parties prenantes. L'étude des services écosystémiques – production de bois d'œuvre, protection contre les risques naturels comme les avalanches, les éboulements et les flux de débris, valeurs de protection de la nature et aménités liées au paysage, échanges entre ces services dans le cadre d'une exploitation forestière multifonction – doit s'effectuer à l'échelle locale et régionale. Pour une application fructueuse, l'intégration appropriée et transparente des avis et valeurs des parties prenantes est extrêmement importante. Pour contribuer à ce type de procédures d'évaluation et de planification, nous avons développé un outil d'évaluation Web. Cette présentation expose les fondements conceptuels de l'outil d'aide à la prise de décision, sa mise en œuvre et illustre son fonctionnement en présentant les données d'une étude de cas du projet MOTIVE. L'outil peut être utilisé par des décisionnaires individuels ou au sein d'un groupe où les parties prenantes participent dans un environnement type atelier. À l'aide d'une interface Web, l'utilisateur est guidé au travers de la procédure d'évaluation qui se fonde sur les principales phases de prise de décision : (1) structuration des problèmes (sélection des cas, définition des objectifs et lots d'indicateurs associés), (2) formulation des préférences (importance des indicateurs et identification des seuils de tolérance en matière d'impact du changement climatique), et (3) évaluation. Plusieurs cycles de cette procédure peuvent être effectués pour éprouver l'efficacité des clauses de préférence alternatives et des pratiques de gestion sur la vulnérabilité résiduelle. Les indicateurs servent à évaluer la performance de la gestion forestière pour les services écosystémiques demandés. Les données de performance des trajectoires de gestion pour tout type de forêt peuvent être fournies par des simulations écosystémiques antérieures ou l'avis qualitatif d'experts stocké dans la base de données. Les indicateurs sont alors agrégés pour une surface de vulnérabilité bidimensionnelle (Luers, 2005) qui caractérise la sensibilité ainsi que les relations état/seuil des services écosystémiques au changement climatique. La position d'un programme de gestion spécifique et son déplacement sur la surface de vulnérabilité le long d'une trajectoire temporelle servent aussi de moyen de communication efficace pour les non-experts et les laïcs chez les parties prenantes. L'exposé discute enfin des avantages et des limites potentielles de l'outil actuel ainsi que de ses améliorations possibles.

# ‘No manual for the future’: helping private woodland owners to adapt to climate

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Two-thirds of the woodland in Great Britain is in private ownership. Forest governance is multi-scalar in Great Britain: forestry is regulated at UK level by the Forest Act 1967, but forest policy is devolved to the constituent countries, and hence goals, incentive structures and delivery services differ between England, Wales and Scotland. The challenges of climate change include not only revised species choices, but enhanced resilience through more diverse silvicultural systems and a more connected (or permeable) landscape. With such a significant private sector, set in a mosaic of small scale habitats, diverse land use and ownership structures, understanding the perspectives of private woodland owners and managers in relation to climate change and perceived options for dealing with uncertainty and change becomes an essential part of the national? climate change adaptation strategy. In this study we focus on Wales, which has recently produced a range of new guidance materials to encourage woodland managers to diversify species choice and silvicultural systems, and where policy encourages a move towards ‘low impact silviculture’ or continuous cover forestry. A recent survey of farmers reveals the difficulties of relying on information supply and conventional extension approaches to advocate woodland management. Until now the attitudes, values and perceptions of Welsh forest owners have not been researched. This study provides an insight into the different categories of owners, and influences on their attitudes, opinions and management activities. Results are currently being analysed but initial indications show that small scale woodland owners are not generally convinced of a need to adapt, and of those who are, most believe that it is best to rely on using native species. A significant number of small scale owners do not seek advice and are not reached by information campaigns. Estate owners show more of a tendency to manage for overall resilience, and have for long been pioneers of continuous cover forestry; they are more often seen as leaders than as adopters of silvicultural change. However, respondents complain about what they perceive as inconsistency in advice provided by government services, and many are not comfortable with the notion of uncertainty. Recent high profile outbreaks of tree disease are more often perceived as a call for action, than climate change itself. Our paper concludes with recommendations for engaging with private woodland owners in climate change adaptation, including communication strategies and suggested focus on areas of primary concern to the owners in different sectors.

**« Pas de mode d'emploi pour l'avenir » : aider les propriétaires forestiers privés à s'adapter au climat**

Les deux tiers des zones boisées de Grande Bretagne appartiennent au secteur privé. La gouvernance forestière est répartie sur plusieurs échelles en Grande Bretagne : la sylviculture est réglementée au niveau du Royaume-Uni par la loi sur la Forêt de 1967, mais la politique forestière incombe aux pays constituants, et donc les objectifs, les structures d'incitation et les services apportés varient entre l'Angleterre, le pays de Galles et l'Écosse. Les difficultés provoquées par le changement climatique comprennent non seulement la révision du choix des espèces, mais une amélioration de la résilience par des systèmes de sylviculture plus diversifiés et un paysage plus connecté (ou perméable). Avec un secteur privé si important, composé d'une mosaïque d'habitats à petite échelle, d'utilisations diversifiées des terres et de structures de propriété variées, la compréhension des perspectives des propriétaires et des gestionnaires forestiers privés associées au changement climatique et des choix envisagés pour aborder l'incertitude et le changement devient une composante essentielle de la stratégie nationale d'adaptation au changement climatique. Dans cette étude, nous nous concentrons sur le pays de Galles, qui a diffusé récemment un ensemble de nouveaux documents de recommandations pour encourager les gestionnaires forestiers à diversifier le choix des espèces et les systèmes de sylviculture et où la politique encourage une orientation vers une « sylviculture à faible impact » ou une gestion forestière à couvert continu. Une enquête récente réalisée auprès des propriétaires révèle les difficultés de se reposer sur la simple divulgation d'informations et le développement forestier traditionnel pour promouvoir la gestion forestière. Jusqu'à maintenant, les attitudes, les valeurs et les perceptions des propriétaires forestiers gallois n'ont pas été étudiées. Cette étude décrit les différentes catégories de propriétaires ainsi que les éléments influençant leurs attitudes, opinions et activités de gestion. Les résultats sont en cours d'analyse, mais les premières indications montrent que les petits propriétaires forestiers ne sont généralement pas convaincus du besoin de s'adapter, et ceux qui le sont pensent pour la plupart qu'il est préférable de se fier à l'utilisation des espèces locales. Un nombre important de petits propriétaires ne sollicitent pas de conseils et ne sont pas atteints par les campagnes d'information. Les propriétaires publics sont davantage enclins à la gestion pour une résilience globale, et sont depuis longtemps les pionniers de la gestion forestière à couvert continu. Ils sont plus souvent considérés en tant que meneurs plutôt que suiveurs du changement dans la sylviculture. Toutefois, les personnes interrogées se plaignent de ce qu'elles perçoivent comme une incohérence des conseils apportés par les services gouvernementaux, et beaucoup ne sont pas à l'aise avec la notion d'incertitude. Les épidémies récentes et très évidentes ayant touché les arbres sont souvent perçues davantage comme un appel à l'action que comme le résultat du changement climatique lui-même. Notre article conclut avec des recommandations pour s'engager aux côtés des propriétaires forestiers privés et s'adapter au changement climatique, avec notamment des stratégies de communication et la suggestion de se concentrer sur des domaines de grande préoccupation des propriétaires dans différents secteurs.

# Modelling for Knowledge Update in Adaptive Forest Management

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Adaptive forest management takes the advantage of forthcoming information about the environment and forest state to update the optimal decision. We develop a modelling concept for the knowledge update towards perception of future climate change which may ask for the change of optimal management schemes. We consider a handful set of trajectories including extreme and no change of climate state. Climate uncertainty is defined by a normal i.i.d. shock around the true underlying model. It is assumed that determination of true climate scenario is just a matter of time and by means of observations and monitoring it would be unfolded in the near future. We illustrate a case of forest owner in the Netherlands who is not convinced with the occurrence of climate change or set of scenarios. The value of his decision, however, may be affected by new climate conditions and urge him to consider the stochastic variation of climate states. The time needed to convince the forest owner for accepting the fact of climate change and integrating the risk in the decision-making will be depending on i) initial perception, ii) knowledge achieved in time and iii) the value of adaptive measures suitable for new conditions. However, we show that the economic value of such an adaptive approach would be higher if a reasonable change in climate state occurs asking consequently for a change in optimal decision.

# La modélisation au service de la mise à jour des connaissances pour la gestion forestière adaptative

La gestion forestière adaptative tire profit des informations futures sur l'état de l'environnement et des forêts pour éclairer une prise de décision optimale. Nous développons un concept de modélisation pour la mise à jour des connaissances en matière de perception du futur changement climatique qui pourrait appeler des modifications aux programmes de gestion optimaux. Nous étudions quelques lots de trajectoires, y compris des états extrêmes et des cas d'absence de changement. Les incertitudes climatiques se définissent par un choc normal distribué de manière indépendante et identique autour du réel modèle sous-jacent. On suppose que la détermination du scénario climatique réel n'est qu'une question de temps et que, par le biais d'observations et de contrôles, il sera révélé dans un avenir proche. Nous illustrons un cas de propriétaire forestier aux Pays-Bas non convaincu de l'occurrence du changement climatique ou des lots de scénarios. La valeur de sa décision, néanmoins, peut être impactée par les nouvelles conditions climatiques et l'inciter à envisager la variation stochastique des états climatiques. Le temps nécessaire pour convaincre le propriétaire forestier d'accepter le changement climatique et d'intégrer les risques dans la prise de décision dépendront de i) la perception initiale, ii) les connaissances acquises dans le temps et iii) la valeur des mesures adaptatives adaptées aux nouvelles conditions. Néanmoins, nous montrons que la valeur économique d'une telle approche adaptative serait plus élevée si un changement raisonnable de l'état du climat survient, qui appellerait par conséquent un changement dans la décision optimale.

# FOREST CHANGE - Generating, Integrating and Delivering Climate Change Knowledge to Support Forest Sector Adaptation in Canada

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Catherine Ste-Marie "Forest Change" is a Canadian Forest Service initiative that aims at the systematic documentation of the responses of Canadian forests to climate change based on empirical evidence. This framework is being built to integrate monitoring information and scientific knowledge, including projected impacts, to enable the integrated assessment of multiple interacting impacts of climate change on Canada’s forest ecosystems. This initiative will make climate change knowledge more available, usable and applicable, thus enabling more direct efforts toward the planning and implementation of adaptive measures. Climate change effects on Canada’s forest are already evident. Observed impacts include increased extreme weather events (drought, windthrow, etc.) and altered disturbance regimes (fire, insect outbreaks). Increasing temperatures have also resulted in earlier spring phenological events and northern (and altitudinal) shifts in plant and animal ranges. These impacts and the fact that forest management requires long-term planning have important implications for Canada’s ability to achieve sustainable forest management objectives. The need for adaptation has been recognized, and is a cornerstone of the National Forest Strategy of the Canadian Council of Forest Ministers. The capacity of the forest sector to incorporate climate change consideration into forest management planning and practices is often limited by the lack information and tools. A large amount of scientific knowledge has been developed in the last decades but this knowledge has evolved within the boundaries of traditional bio-physical disciplines, focused on specific problems. Integrating multidisciplinary knowledge will increase our understanding and ability to make projections about the response of forests to a changing climate, including productivity, renewal and succession, and the adaptive capacity of forest-dependent communities. Also, scientific knowledge on the observed and expected impacts of climate change on forests is being generated at an accelerating pace, but the rate of transfer to users has not been keeping up. There is an increasing demand for scientific knowledge that is applicable for use by practitioners and policy-makers at appropriate spatio-temopral scales. There is also significant uncertainty associated with both the magnitude of projected climate shifts, and the contributing and resulting forest processes and their interaction. The "Forest Change" initiative is designed to fill these gaps and better equip decision-makers for tackling climate change issues. Forest Change is also meant to support the evaluation of projection uncertainties and the monitoring and assesssment of impacts and adaptation processes as they unfold.

## FOREST CHANGE – Génération, intégration et concrétisation des connaissances en matière de changement climatique pour soutenir l'adaptation du secteur forestier au Canada

« FOREST CHANGE » de Catherine Ste-Marie est une initiative de l'office des forêts canadien qui vise à documenter systématiquement les réponses des forêts canadiennes au changement climatique sur la base de preuves empiriques. Ce cadre est élaboré pour intégrer les informations de suivi et les connaissances scientifiques, y compris les impacts projetés, et permettre l'évaluation intégrée des impacts multiples en interaction du changement climatique sur les écosystèmes forestiers canadiens. Cette initiative améliorera la disponibilité des informations sur le changement climatique, leur utilisation et leur appplication, en permettant ainsi de concentrer les efforts sur la planification et la mise en œuvre de mesures adaptatives. Les effets du changement climatique sur la forêt canadienne sont déjà manifestes. Les impacts observés incluent l'augmentation des événements météorologiques extrêmes (sécheresse, chablis, etc.) et une modification des régimes de perturbation (incendies, invasions d'insectes). La hausse des températures a également entraîné des événements phénologiques de printemps plus précoce et des migrations vers le Nord (et en altitude) chez certaines espèces de plantes et d'animaux. Ces impacts et le fait que la gestion forestière requiert une planification à long terme ont des implications importantes dans la capacité du Canada à atteindre ses objectifs de gestion durable à long terme. Le besoin d'adaptation est reconnu et sert de pierre angulaire à la National Forest Strategy du conseil canadien des ministres des forêts. La capacité du secteur forestier à intégrer les aspects du changement climatique dans la planification et les pratiques de gestion forestière est souvent restreinte par le manque d'informations et d'outils. Une large somme de connaissances scientifiques a été développée dans les dernières décades mais celles-ci ont évolué dans les limites des disciplines biophysiques traditionnelles, centrées sur les problèmes spécifiques. L'intégration de connaissances pluridisciplinaires va augmenter notre compréhension et notre capacité à formuler des projections sur la réponse des forêts au changement climatique, y compris productivité, renouvellement et succession, ainsi que la capacité adaptative des communautés dépendantes des forêts. Par ailleurs, les connaissances scientifiques sur les impacts observés et attendus du changement climatique sur les forêts sont en cours de génération à une vitesse accélérée, mais le taux de transfert aux utilisateurs n'a pas suivi le rythme. Il existe ainsi une demande croissante pour les connaissances scientifiques applicables par les experts des forêts et les décisionnaires à des échelles spatiotemporelles appropriées. Il existe également une incertitude significative associée à la fois à l'amplitude des changements climatiques projetés et à la contribution des procédures forestières qui en découlent et à leur interaction. L'initiative « FOREST CHANGE » est conçue pour combler ces écarts et mieux armer les décisionnaires pour lutter contre les questions liées au changement climatique. Elle est également destinée à soutenir l'évaluation des incertitudes de projection et à accompagner le suivi et l'évaluation des impacts et des procédures d'adaptation au fur et à mesure de leur déploiement.

# POSTERS

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| Do afforestation subsidies in the Czech Republic contribute to climate change adaptation? | Mr. Vojtech KOTECKY - Charles University Environment Center - Czech Republic |
| Afforestation programs to reduce climate change impacts on forest lands in Kardzhali region (Bulgaria) | PhD Student Borislav YANGYOZOV - Forest Research Institute – Bulgaria |
| Forest water budget as affected by stand composition and tree density | Dr Nathalie KORBOULEWSKY - Cemagref - France<br>Dr Philippe BALANDIER - Cemagref - France<br>Vincent SEIGNER - Cemagref - France<br>Gwenaël PHILIPPE - Cemagref - France<br>Yann DUMAS - Cemagref - France |
| Forests and Climate Change - a Swiss Research Program | Dr. Peter BRANG - WSL Swiss Federal Institute of Forest, Snow and Landscape Research - Switzerland Dr. Sabine AUGUSTIN - FOEN Federal Office of the Environment – SwitzerlandDr. Julia BORN - of Forest, Snow and Landscape Research - Switzerland |
| PlantaComp: a forestry experimentation network for studying adaptation to climate change | ANGER Christel - INRA - France<br>SERGENT Anne-Sophie - INRA - France |

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| Adaptations of mountain forest management to climate change: can we maintain mixed uneven-aged and productive forests? | Valentine LAFOND - Cemagref de Grenoble - France<br>Thomas CORDONNIER - Cemagref de Grenoble – France<br>Benoît COURBAUD - Cemagref de Grenoble - France |
| CON ECO FOR (Monitoring Forest Ecosystem): an integrated approach to save the forests by the negative effects of climate change. | Maria SOPRANO - CNR- Istituto Biologia Agro-ambientale e Forestale- U.O.S. di Napoli - Italy Salvatore APUZZO - Regione Campania –Settore foreste - Italy Emma SORRENTINO - CNR- Ufficio Attività Relazioni Internazionali (UARIE)- Napoli - Italy Aniello APUZZO - Agrostudi- Castellammare di Stabia (NA) - Italy |
| Natural regeneration and Climate Change adaptation in Pinus nigra Arn. stands from reforestation projects | Dr Francesca BOTTALICO - DEISTAF, Università di Firenze - Italy Dr Paola BRUNDU - Ente Parco Nazionale dell'Arcipelago di La Maddalena - Italy Dr Chiara LISA - DEISTAF, Università di Firenze - Italy<br>Prof.ssa Susanna NOCENTINI - DEISTAF, Università di Firenze - Italy Dr Nicola PULETTI - DEISTAF, Università di Firenze - Italy |
| The influence of mixed tree species stands compared with single tree species stands on within- and between-stand forest biodiversity | Dr. Nadia BARSOUM - Forest Research - United Kingdom |
| Stabilizing the production function by the mixture of tree species | Dr Patrick VALLET - Cemagref - France<br>Dr Thomas PEROT - Cemagref - France<br>Maude TOIGO - Cemagref - France |
| The adaptation of French forests to climate change by species substitution | Hervé LE BOULER - CNBF – France Christel ANGER - INRA – France Vincent BADEAU - INRA – France Thierry LAMANT - ONF – France Philippe RIOU-NIVERT - CNPF – France |
| The TRAITAUT project : functional TRAITs and AUToecology of tree species | Alice MICHELOT – GIP ECOFOR c/o CIRAD - France<br>Sophie GACHET - Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale - UMR CNRS 7263 / IRD 237 / Aix-Marseille Université – France Myriam LEGAY - Office National des Forêts - Pôle Recherche et Développement - - France Guy LANDMANN - GIP ECOFOR c/o CIRAD - France |
| AFORCE, a network devoted to the adaptation<br>of forests to climate change | Olivier Picard – IDF - France<br>Céline Perrier – IDF - France |
| **MITIGATION** | |
| ***Title*** | ***Authors*** |
| Mitigating climate change by utilization of energy potential of Ukrainian forests | Prof. Petro LAKYDA - NUBiP of Ukraine - Ukraine Dr. Roman VASYLYSHYN - NUBiP of Ukraine - Ukraine Dr. Sergiy ZIBTSEV - NUBiP of Ukraine - Ukraine Ivan LAKYDA - NUBiP of Ukraine - Ukraine |
| An economic analysis of afforetation for provision of multiple ecosystem services, with some implications for carbon forestry in Ukraine | Maria NIJNIK -The James Hutton Institute Craigiebuckler, Aberdeen, AB15 8QH - United Kingdom Albert NIJNIK - Environmental Network Limited, United Kingdom-Germany-Ukraine Arie OSKAM - Agricultural Economics and Rural Policy, Wageningen University - Netherlands |

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| Uncertainty of soil carbon sink estimate - case Finnish GHG inventory | Aleksi LEHTONEN and Juha HEIKKINEN -Finnish Forest Research Institute, Metla, Vantaa - Finland |
| Fantallometrik : the international platform for forest volume, biomass and carbon assessment | Dr. Matieu HENRY - Food and Agriculture Organization of the United Nations - Italy Dr. Carlo TROTA - University of Tuscia - Italy Prof. Ricardo VALENTINI - University of Tuscia - Italy Dr. Nicolas PICARD - CIRAD - France Dr. Laurent SAINT-ANDRE - CIRAD, INRA - France |
| Importance of carbon storage in forest biomass and soils for climate change mitigation: case of Madagascar | Dr. Herintsitohaina, RAZAKAMANARIVO-RAMARSON - Laboratoire des Radio Isotopes - Madagascar Pr. Tantely, RAZAFIMBELO - Laboratoire des Radio Isotopes - Madagascar Erika, RAKOTOMALALA - Engref AgroParitech - France |
| Carbon sequestration of urban trees in Hamburg, Germany- a comparison of three different biomass equations | Dipl. Ing. Agrar Stefanie POEPKEN - von Thuenen Institute, Institute for Worldforestry - Germany Prof. Dr. Michael KOEHL - von Thuenen Institute, Institute for Worldforestry - Germany |
| Scenarios of carbon balance of forest land in Finland under the effect of different levels of wood use and climate change | Dr. Risto, SIEVÄNEN - Finnish Forest Research Institute – Finland Mr. Olli, SALMINEN - Finnish Forest Research Institute – Finland Dr. Aleksi, LEHTONEN - Finnish Forest Research Institute – Finland Dr. Jari, LISKI - Finnish Environment Institute – Finland Dr. Kimmo, RUOSTEENOJA - Finnish Meteorological Institute - Finland |
| A trading system for forest management carbon sink credits | Director Martin GAVELIUS - PWC - Sweden Environmental manager Anders LUNDKVIST - LKAB - Sweden Dr Hans WINSA - Sveaskog - Sweden |
| la valorisation de la séquestration du carbone en forêt privée en France | Olivier PICARD - IDF / CNPF – France |
| **SOCIOECONOMIC ASPECTS OF CLIMATE CHANGE KNOWLEDGE MANAGEMENT** | |
| ***Title*** | ***Authors*** |
| Economically Optimal Adaptation of Forest Management in the Changing Climate | Raisa, MÄKIPÄÄ - Finnish Forest Research Institute - Finland Tapio, LINKOSALO - Finnish Forest Research Institute – Finland Sami, NIINIMÄKI - University of Helsinki - Finland Annikki, MÄKELÄ - University of Helsinki - Finland Olli, TAHVONEN - University of Helsinki - Finland |
| Mobiliser les connaissances indigènes des peuples forestiers à la définition concertée et la mise en Suvre participative des stratégies d’atténuation et d’adaptation au Changement Climatique : lexpérimentation de la matrice « KerDST TM» dans des projets forestiers tropicaux en Afrique de lOuest. | Ettien BROU - Research in Ecological economics, Eco-innovation&tool Development for Sustainability - University of Versailles ( REEDS -UVSQ) – France |
| Community forestry as a measure against climate change | Mr. KESSE, Brou - Ministry of environment and sustainable development - Cote d'Ivoire |

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| The value of process-based forest models for economic assessments of greenhouse gas emission abatement in Europe | Uwe A. SCHNEIDER - Hamburg University - Germany Georg KINDERMANN - IIASA - Austria Tapio LINKOSALO - Finnish Forest Research Institute - Finland Anabel SANCHEZ - CREAF, Center for Ecological Research and Forestry Applications - Spain Werner RAMMER - University of Natural Resources and Life Sciences - Austria |
| Integrating a Eucalyptus fastigata carbon yield calculator in WEFES, a web explorer of forest environmental services | PhD, João ,PALMA - Forest Research Centre, School of Agronomy, Technical University of Lisbon - Portugal PhD, Dean, MEASON - SCION - New Zealand |
| The right trees on the wrong places? A spatially explicit approach to unravel the efficiency of the Scottish forestry regulatory framework in the face of climate change | Munoz-Rojas MORENES J, Gonzales PUENTE M CORTINES-GARCIA f., GIMONA A., NIJNIK M. |

# OBSERVED AND EXPECTED IMPACTS

# Identification of drivers determining species distribution of ectomycorrhizal fungi along a climatic gradient in Scotland

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Ectomycorrhizal fungi associate with the roots of forest trees where they enhance nutrient and water uptake, promote seedling establishment and play an important role in nutrient cycling. Predicting the response of ectomycorrhizal fungi to climate change is an important step to maintaining future forest productivity. Current predictions are limited by an incomplete understanding of existing ectomycorrhizal fungal distributions and the significance of climatic drivers in determining community composition. When suitable species distribution data are available, assessing distributions along existing climatic gradients is a useful technique to evaluate the potential for community shifts under climate change. By simultaneously sampling gradients of other potential drivers of community change, such as nitrogen pollution, it is possible to assess the relative importance of climate in determining community composition. Scotland provides a good regional scale study area as there are major gradients in both climate and nitrogen deposition. These gradients run perpendicular to each other, allowing assessment of the impact of climate and pollution on ectomycorrhizal fungal communities independently. To identify patterns of community composition in ectomycorrhizal fungi along climatic and nitrogen deposition gradients in Scotland, fungal communities were analysed from 15 natural Scots pine (Pinus sylvestris) forests. Fungal species were identified from ectomycorrhizal pine roots by sequencing the ITS region using fungi-specific primers. Non-metric multidimensional scaling was used to assess the significance of a range of 12 climatic, pollutant and edaphic drivers on community composition across the 15 forests. Vector fitting showed temperature, rainfall and carbon to nitrogen ratio of the soil to be most important in determining fungal community composition. Nitrogen pollution appeared to have relatively little effect on community composition, in contrast with findings from previous work on regional scale nitrogen deposition gradients. This work indicates that climatic parameters are important in determining the distributions of ectomycorrhizal fungi in Scotland, and therefore we may expect distributions to be responsive to climate change. Further work is required to identify which species are most sensitive to environmental change and how community change will affect forest productivity and ecosystem functioning.

## Interactions between soil texture, nocturnal transpiration and root hydraulic redistribution: consequences for future carbon and water budgets of pine plantations in the southern U.S.

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Prof. Jean-Christophe DOMEC - North Carolina State University/ENITA Bordeaux - United States
Prof. Asko NOORMETS - North Carolina State University - United States
Drs. Michael GAVAZZI, Emrys TREASURE, Ge SUN, Steve MCNULTY - USDA Forest Research - United States
Prof. John KING - North Carolina State University - United States

Deep root water uptake and hydraulic redistribution (HR) play an important role in water and carbon budgets of forest ecosystems. However, little is known about the impacts of soil properties and nocturnal transpiration on HR. Using extensive datasets from three loblolly pine plantations with contrasting soil characteristics, nitrogen (N) fertilisation and elevated $CO_2$ treatments and the process-based model MuSICA, we show that HR mitigates the effects of soil drying in summer and has important implications for the carbon sink potential of these ecosystems. HR increases dry season (July-October) tree transpiration (T) by up to 40%, which affects NEE through major changes in gross primary productivity (GPP). Under future climatic and N-fertilization conditions, T is expected to decrease by 15-25% (75-150 mm/year) because of a negative effect of N fertilization on root density and tree water transport capacity, and a larger porportion of this transpiration occurs at night. Reduced annual precipitation will limit water availability and decrease all carbon fluxes, including NEE and ecosystem respiration. We found that increases in air temperature, vapor pressure deficit and $CO_2$ would reduce HR by up to 25% under certain soil conditions and would further limit the resilience of trees to reduced precipitation.

# The long-term trend in leaf delta13C in two tree species from Northern Amazonia indicates an increase in water-use efficiency over the last two centuries

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Dr. Damien BONAL - INRA, UMR EEF - France
Dr. Paulina PINTO - INRA, UMR LERFOB - France
Dr. Jérôme OGEE - INRA, UMR EPHYSE - France

The impact of global changes, including increasing atmospheric CO2 concentration and climate change on the biology of tropical rainforest trees is still largely unknown. Because tropical forests play an important role in carbon and hydrological cycles, a better characterization and understanding of the long-term influence of environmental changes on the functioning of tropical tree species, particularly with regards to CO2 and H2O acquisition and utilization, is needed. The variations of intrinsic water-use efficiency during the last two centuries were investigated based on the dual analysis of delta13C and delta18O in leaves of two tropical rainforest species (Dicorynia guianensis; Humiria balsamifera) that are abundant in the Guiana shield (Northern Amazonia). Leaf samples were collected in different inter-national herbariums to cover a 200 year time-period (1790–2004) and the whole Guiana shield. Using models describing carbon and oxygen isotope fractionations during photosynthesis, different scenarios of change in intercellular CO2 concentrations inside the leaf, stomatal conductance, and photosynthesis were tested in order to understand leaf physiological response to increasing air CO2 concentrations. Our results confirmed that both species displayed physiological response to changing air CO2 concentrations. For both species, we observed a decrease of about 1.7‰ in delta13C since 1950, corresponding to an increase in water-use efficiency of 23.1% and 26.6% for Humiria and Dicorynia, respectively. No clear change in delta18O were observed for Humiria over this period. Our simulation approach revealed that an increase in photosynthesis rate, rather than a decrease in stomatal conductance, explained the observed trends for these tropical rainforest species. This improvement in water-use efficiency, which appeared to be simply related to the availability of CO2 in the air, might help to compensate the negative effects on tree growth of future potential increase in water limitation.

# Comparing the accuracy of a process-based (3PG), a hybrid (Glob3PG) and an empirical (Globulus 3.0) model against long term permanent plot data from Eucalyptus globulus Labill.

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Models used to simulate forest dynamics can be classified in three groups: empirical growth and yield models, process-based models and hybrid models. The empirical models are developed using statistical techniques and can be used as good management and planning tools for productivity forecasts. Although are not sensitive to possible environmental changes such as droughts, pests, diseases or climate change in general. In contrast, process-based models offer the possibility to take into account a changing environment as they are developed based on the understanding of forests behavior, that is, the dynamics established between the plant and the soil and the processes concerning the nutrients and water cycles. Finally, the hybridized models combine both type of models (empirical and process-made) and join the advantages they may present: the reliability and practicality of empirical models with the flexibility offered by physiological models. In Portugal, Eucalyptus globulus Labill. plantations cover 646.700ha, that is around 21% of the total forest area of the country and is an important source of raw material for the pulp industry and for production of bioenergy. In Portugal some empirical growth models have been developed for eucalyptus such as Globulus 3.0 while the most commonly used physiological model, 3PG was tested and parameterized for the country. Also the hybrid model Glob3PG was developed by linking 3PG and Globulus 2.1 through the stand level allometric relationship between basal area and woody biomass. The three models were integrated in two stand level simulators: the empirical model (Globulus 3.0) was integrated into GLOBALL simulator while the hybrid (Glob3PG) and the process-based model (3PG) into 3PGout+ simulator. Both tools were used to simulate the evolution of each plot. The main objective of this presentation is to compare the performance of the two simulators including the three types of growth models to forecast first rotation production of Eucalyptus globulus Labill. against long-term permanent plot data in Portugal.

# Evaluation of 3PG and GLOB3PG models to predict growth of Eucalyptus globulus coppice stands

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In 2009, Portugal was the fourth biggest pulp producer in Europe. Eucalyptus globulus L. is the second most representative forest species in Portugal covering nearly 740,000 hectares. Eucalyptus plantations are mainly used by the pulp and paper industry being managed as one plantation followed by up to two coppices. Since the 90's several empirical growth models have been developed to forecast the evolution of these plantations, Globulus 3.0 model is the most commonly used one. However, the increasing need to assess the impacts of climate change on forest ecosystems has reinforced the use of prediction tools integrating process-based models. Over the last decade, the application of 3PG process-based model has been studied for E. globulus in Portugal. However, the model's performance for coppice stands has never been tested. 3PG model was integrated into 3PG-out+ stand simulator which also integrates GLOB3PG. The latest model is a variant of 3PG that provides more detailed outputs for forest managers, namely: basal area, stand and merchantable volumes. The two model variants were used to assess the ability of 3PG-out+ to simulate coppices. A set of permanent plots measured throughout consecutive rotations was selected. A total of 22 plots was used as input for 3PG-out+ in three simulation series varying in the measurement used as the starting year of simulation. The first simulation series starts with the first coppice measurement, but because most coppices started being measured after the shoots' selection, simulations from first coppice measurement onwards, miss-represented the transition between rotations and the thinning of the shoots. In order to counterbalance this, another series of simulations starting with the last measurement of the 1st rotation was considered. A final simulation series started with first measurement of the 1st rotation which will allow determining whether any deviations result from coppice's characteristics or if they are due to the models' lack of efficiency regardless of rotation. These simulation series served as input to the two variants of 3PG growth model. Results include comparisons obtained with Globulus 3.0 empirical growth model. Prediction errors were calculated based on the differences between observed and estimated values for each plot.

# Possible climate change impacts on forests in Romania

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The paper presents a series of possible climate change impacts on the Romanian forests. After a systematic overview, the possible impacts are analysed through several case studies. For these analyses, the climate change scenarios produced by Global Climate Models (GCM) are downscaled to regional and local level, with a special attention given to the climate parameters that highly affect the forest ecosystems considered. A series of possible consequences on forests are synthesised, from changes in the range, productivity and services, to environmental and biotic threats, respectively modifications in the species interactions. The case studies are mainly focusing the Romanian forests border regions, namely the lower limit, located toward the steppe zone and the upper limit, in the mountains. The forests adapted to extreme dry conditions, comprising xerophilous oaks (Quercus pubescens etc.) represent a valuable resource, especially in the context of the drying trend. The drought frequencies modifications would affect those sensitive ecosystems. Despite their apparent resilience, natural regeneration might be affected (as reported in several plots in south eastern Romania), requiring special management schemes. As regards the mountain forest ecosystems, there are two important climate change related issues approached: the mountain climate variability (interacting with the global and regional trends) and the vital environmental services provided by those woodlands. The forest management decision making process requires climate data at stand level (forest management units), and consequently, for mountain regions it is not enough to use regional climate change scenarios, because the local climate conditions are modified on the mountain slopes, in accordance with aspect, inclination and shading. The high altitude forests located on very shallow soils, lime stone bedrock and steep slope are surprisingly sensitive to drought. The paper also analyses the complex interactions between the expected trends in extreme events (storms, gails etc.), the ways in which the mountain forest services would be affected, outlining the threatening feedbacks on water regulating and erosion control.

## Gradients as indicators of climate change impacts on European forests

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This study presents results of a pan-European literature review on climatic and biophysical gradients, i.e., altitudinal, latitudinal and precipitation gradients. By analyzing variability of climate responses of forests along these gradients, we aim to increase the understanding of how future climate change might impact European forests. A special focus of this study is the possible changes in forest composition, structure and growth. In addition, we consider forest management responses as a means of providing valuable information on improved methods for adaptive forest management in parts of Europe where the projected climate change resembles contemporary climatic conditions. We analyze peer-reviewed work and grey literature from numerous European countries, covering large latitudinal (or bioclimatic) gradients (from Boreal to Mediterranean), altitudinal gradients (from low-lying to mountainous areas), precipitation gradients as well as a wide range of climatic influences (from Atlantic to Continental climates).
This contribution is based on the work of COST Action FP0703 ECHOES Working Group 1 “Impacts” (http://www2.gip-ecofor.org/echoes).

## CLIMFOR: Modeling climate change impacts on tropical forest biodiversity of French Guiana

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Tropical rainforest ecosystems of French Guiana rank among the rainforests least impacted by landscape fragmentation and degradation, but they are estimated to be among the most vulnerable to climate change. The present project will explore the climate change component of the global change effects on four ecosystem services (Plant species diversity, Plant functional diversity, Carbon storage, Timber production) of French Guianan tropical forests. Currently, no reference map for these four ecosystem services is available in Northern French Guiana, which concentrates 95% of the population of this overseas Region. By integrating meteorological, tree census and functional trait data through novel modeling approaches, we will be able (i) to design such reference maps, (ii) to model the effects of three components of the climate change (water stress, irradiance, temperature) on the four predefined ecosystem services through forest dynamic models (growth, mortality) and (iii) to use the parametrized models of (ii) in order to explore the consequences of a panel of climate change scenarios on ecosystem services. We will then examine the extent to which the current design of protected areas in northern French Guiana is optimal for preserving the diversity of tropical forest ecosystems. We will also explore the climate change consequences on the long-term population viability of timber trees and on the forest carbon storage potential. By explicitly including climate indicators into the forest dynamic models and by explicitly linking the spatial patterns of ecosystem services to the spatial patterns of climate indicators, our project permit a formal incorporation of biodiversity as a driving factor in the sensitivity of tropical forest ecosystem services to climate change.

## Can the within-population phenological diversity in oak be explained by biotic (powdery mildew) and/or abiotic (heat and chilling requirements) selection pressures?

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The current climate change is modifying the life cycle of many organisms. Phenology, due to the determinant role of temperature, is one of the first characteristic visibly affected. Previous studies along altitudinal gradients in the Pyrenees demonstrated a local adaptation of oaks (Quercus petraea) for phenology, with populations from low elevation flushing earlier than high elevation ones. Despite this local adaptation, a high within-population genetic diversity is maintained for this trait, with a decreasing trend with elevation. In order to explain this paradox, we focus here on biotic (pathogenic agent, powdery mildew) and abiotic (heat and chilling requirements) characteristics of natural selection. These two factors could act in opposite directions as evolutionary forces on oaks phenology, generating a diversifying selection. Our objective is thus to finely characterize these selection pressures and their variations along an altitudinal gradient. The altitudinal gradient is located in the French Pyrenees, with oak populations ranging between 150m and 1750m asl. Chilling and heat requirements were also monitored on beech (Fagus sylvatica) along the same gradient, in order to compare this closely related species in the Fagaceae family. The first results allowed us to characterize chilling and heat requirements for leaf unfolding, and thus refine predictive phenological models. Moreover, spatio-temporal dynamics of inoculum production and infection by powdery mildew was studied in the different populations and in “common garden”. Subsequently, a retrospective study of late frosts during the last fifty years on this gradient will be made via a modeling approach. In the end, the construction of “selective values – leaf unfolding” curves would permit to characterize the intensity and direction of the selection exerted on phenology by cold and powdery mildew.

# The forest growth model 4C – validation at nine European sites

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In the framework of the MOTIVE (Models for Adaptive Forest Management) project the process-based forest growth model 4C is used to simulate the impact of climate change and elevated carbon dioxide on forest productivity in Europe (see oral presentations submitted to session 3). Before carrying out these analyses, the main processes of the model that are relevant for simulating carbon and water fluxes were validated at nine climatically different sites using detailed measurement data from EUROFLUX/NORDFLUX and ICP Forests Level-II sites. Different output variables (soil temperature, soil water content, and water and carbon fluxes) were analyzed with standard statistical measures (Normalised mean absolute error, Normalised root mean square error, Nash–Sutcliffe model efficiency coefficient, Correlation coefficient). These measures allow a comparison of the goodness-of-fit at the different sites and of the diverse output types. Furthermore, at the site Hyytiälä for which the largest and longest data set is available a graphical analysis of the annual course of soil temperature, soil water and the carbon and water fluxes was carried out. The graphics show that the simulated soil temperature follows the annual course of the measured values and that no systematic bias exists. The soil water content in the organic layer however is mostly not correctly simulated by 4C. The errors apparent in the organic layer propagate into the deeper soil layers but 4C meets the annual pattern of the measured values. The carbon and water fluxes are mostly underestimated by 4C. Especially the net ecosystem exchange will be systematically underestimated at low air temperatures. Overall, the validation statistics as well as the graphical comparison of measured and simulated values of different parameters show satisfactory results, which provide evidence that the model application at a great variety of sites in Europe will give plausible results.

## Soil solution quality researches in different forest communities of Croatia

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In Croatia, forest hydrology research looks into the influence of differently structured forest on the landscape hydrology. The aim is to provide scientific guidance in the development of productive forests that enhance the quantity and quality of seepage water. To investigate the impact of intensified drought on forest regeneration and tree growth special zero tension lysimeters in a field were constructed and used. The paper informs about the soil solution quality under different tree species and about investigations of the water consumption of forest trees and impact of atmospheric deposition on soil solution. Following sedimented substances have been monitored: Cl-, SO42-, NO3-, NH4+, Na+, K+, Ca2+ and Mg2+. Sampling is performed by means of funnels with openings of 78,5 cm2. Funnels are placed under the cover of the tree crowns and in an open area on each plot diagonally by 9 units, each on a plot 30 x 30 m. Plastic zero tension lysimeters are placed in the soil at a depth of 10 cm or beneath the humus horizon. They collect the seeped liquid (seepage) in the soil. The plastic container of lysimeters contains 96% clean quartz sand, which acts as a filter for cleaning the liquids of soil particles. All the instruments and vessels, prior to setting up on the plots, were rinsed with 10% nitric acid, and several times with re-distilled water. Sampling of liquids was carried out at monthly. According to the results of the monitoring our forest ecosystems absorb more sediment particles (wet and dry sedimentation) compared to the control samples on the open area. There was a clearly decreasing trend in the pH of the ground water on moving towards the more acid soils. There is an increased input of deposited matter into our forest ecosystems in all regions. Monitoring which uses this method should be applied to other major forest communities in Croatia in order to get better insight into the impact of the type of forest cover on dry and wet deposition.

# Explaining the occurrence of disturbances in Central European mountain forests over a 20-year period with forest conditions, management and weather data

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Natural disturbances like windthrow, snow breakage and bark beetles (Scolitidae sp.) are critical drivers of forest management and affect composition, structure and functioning of forest ecosystems in Alpine forests in Central Europe. Traditional management paradigms aimed at control and suppression of natural disturbances. However, disturbance history of managed forests shows that this effort widely failed, and natural disturbances have to be taken into account in shaping management strategies. While salvage statistics at national level are frequently used to speculate about the future role of disturbances and about the interrelationships among disturbance factors, analysis based on empirical data at the operational scale of forest management is rare. In this contribution we use the internal records of the Austrian Federal Forests (ÖBf AG) to quantify the development of regular and irregular harvests (i.e. salvage from disturbances) for four regional forest management units (FMU) covering 76000 hectares of mountain forests (twenty-two thousand stands; i.e subcompartments, the smallest operational planning and management unit) over a time span of up to 20 years. We focus on damage from windstorms, snow breakage and bark beetle infestations. The records cover two consecutive ten-year planning periods and comprise of forest site and forest stand attributes representing forest conditions at the beginning of each planning period including the related annual records of wood harvesting activities including the reason for the harvest. Employing yield tables these initial stand-level forest data were extended to provide standing stock estimates for any year of the historic records. The forest data were combined with daily historic weather data including temperature, precipitation, radiation and humidity parameters as well as several storm proxies extrapolated from the network of Austrian weather stations. We present the observed damages and link the occurrence of disturbances to forest and site conditions, management and weather data. Ultimately the scope of the analysis is to include climate sensitive relationships explaining the occurrence of disturbance events in a dynamic forest ecosystem model.

# Parameterization of a set of models predicting daily ecosystem gross primary production, evapotranspiration and soil water content: joint vs. separate parameter estimation of models

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Ecosystem models are widely used in projecting ecosystem carbon and water balances. Carbon and water balances are inherently interlinked by plant functioning, as stomata in leaves regulate both CO2 influx and water outflux. We constructed a set of simple models to predict daily ecosystem gross primary production (GPP), evapotranspiration (ET), and soil water content (SWC). Following the principles of leaf-level models, our ET model depends on our canopy-level GPP model through canopy conductance. Our SWC model, in turn, influences both the GPP and ET models, as soil water is an essential factor in both photosynthesis and ET. Finally, the SWC model depends on the ET model, as ET is one of important processes determining SWC. We estimated the parameters of our models by using classical/frequentist (non-linear least squares regression) and Bayesian (adaptive MCMC) methods. In separate estimations, each model was estimated independently, using only measured data, including the measured values of those input variables that were output variables in other models (e.g. eddy-covariance measured GPP as the input in the ET model). In the joint estimation of the model set, carried out in the Bayesian way with adaptive MCMC, we constructed a joint likelihood function from all predicted variables (GPP, ET, SWC) and corresponding measurements, meaning that we estimated all models at the same time. The objective of this on-going work is to study how the models obtained with joint vs. separate parameter estimation differ in terms of parameter estimates (values, uncertainty) and prediction performance.

## Projecting the Regional Climate Change for East-Central France: potential impacts on Burgundy forests.

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Forest ecosystems are among systems that will be most affected by climate change and this climatic factor is considered as one of the main determinant of the forest species presence. The highly fragmented structure of East-Central French forests requires a fine climate regionalization. Studies of impacts of climate change on a regional scale require climate scenarios at the same scale. However, current scenarios from General Circulation Models (GCM's) are still in short of appropriate spatial resolution for regional impact analysis. Recent results show that high frequency meteorological variability profoundly affects simulated terrestrial carbon dynamics and the associated vegetation structure and composition. Since the 60's, the climatic context of East-Central France and particularly in Burgundy is characterized by a warming of +1.9 ° (± 0.3 ° C). Drought and heat wave of 2003 resulted in a significant decline and mortality of Douglas-fir forests. On the other hand, at the national scale, actual projections already show a drastic reduction of the potential climate area for beech forests. This study aims to understand the vulnerability of these two species to climate change and its consequences, through a detailed characterization of climate variability across Burgundy which may occur in the near future (2030-2050) within the SRES A2 scenario. A first objective is to reduce and quantify biases and uncertainties related to the regionalization of climate projections. The regional climate model ARW/WRF is used to dynamically downscale the IPCC4 A2 climate projections from the Arpege-Climat up to a resolution of 5km. Recent past and future climates, simulated for each grid point, are used to feed an ecological niche model for beech forests, and a terrestrial biosphere model for douglas-fir forests. The idea is to assess potential climate impacts on these two species in order to prioritize base climate variables for their development. Results show the ARW/WRF is able to reproduce the regional climate variability. For temperature, a good agreement appears between observations and simulations ($R^2$~0.95). However, for precipitations, results indicate a quasi-systematic humid bias about 200-300mm for annual cumulative precipitations. Based on such preliminary results, it expected that these simulations will improved our ability to better assess climate change impacts on forests.

## Monitoring of the impact of global change on forest ecosystems

Julie PARGADE - Centre Régional De La Propriété Forestière - France

To complete their research on climate models and experimentations, the searchers need to have information collected from long term observations on the field. It is also important for woodland owners to know how to adapt their management to the climate change, as stands management is something that has to be considered as a long term action. So the CRPF and the Forest research have built a programme of monitoring of several indicators such as tree's phenology, ground flora, crown condition and pest and deseases, meteorology….on permanent plots in Nord Pas de Calais, Picardie and South of England, using national protocols. The objetive is to see how the main regional tree species are affected by global changes in term of growth, sensitivity to current or new pests and deseases, and to see more largely how the forest ecosystem is impacted (are there changes in the herbaceous species, bird species?….). The plots monitored have been selected with the steering committe in order to have a good representation of the regional woodland habitats and stands. The indicators have been chosen in order to be as much as possible in relation with the effect of global changes and to have a quite quick evolution. Several precautions have been taken to install a monitoring system that will last on the long term : i) A steering with many different specialists that will comment our results and will also complete our data base, ii) using national protocols to be able to compare results from different regions, iii) using our current activities and avoid gazworks. This work begun 5 years ago and should continue for several years.

# Assessment of data input quality impact on ecophysiological model performance to predict growth of Eucalyptus globulus plantations, using a Bayesian approach

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Recent international forestry policies tend to emphasize the multi - purpose function of forests. Therefore, it is important to develop and adapt tools that allow understanding of the impact of management on forest multi-functionality under current and changing climate. Process-based models (PBM) allow estimation of site productivity, carbon stores and water use independently of the availability of inventory data, and they also simulate the effects of environmental changes (e.g., drought, pests, diseases, climate change). However, PBM's require significant climate and soil data inputs, which is not always readily available. The main objective of this study was to assess the impact of input data quality on the performances of two models with different complexity. The Bayesian method (i.e., Bayesian model comparison (BMC) and Bayesian model averaging (BMA)) was used to evaluate the models. BMC is based on probability rules and allows evaluating model performances in the light of the available data. Two models that are commonly used in Australia, 3-PG and CABALA were selected for this exercise. 3-PG is simpler than CABALA, less input demanding and it works at monthly time step. CABALA demands more input parameters, detailed site characteristics and works at daily time step. The models were run using different quality of input climate and soil data. We compared model performances using daily measurements, monthly averages and long term averages of climatic variables and soil measured data and maps derived data. Results showed that CABALA performance sensibly decreased when the quality of climatic and soil data decreased; while, 3-PG performances were more sensitive to climatic data quality than soil data. The results from BMC showed that CABALA had almost 60% probability of being the best model to use, when the best data are available. On the contrary, when the quality of the data decreased, 3-PG had the 99% probability of being the best model. Results showed also that using BMA to combine the prediction from the two models significantly improved model forecasts.

# Key drivers of inter-annual variations in oak tree ring growth over the last 100 years in southern Britain and north-eastern France

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Future expected environmental change will require adaptive management of oaks in their native ranges to maintain their contribution to forest ecosystem services. In our study region – southern Britain and north-eastern France – pedunculate oak (Quercus robur L.) and sessile oak (Quercus petraea (Matt.) Liebl.) are keystone native species in their ecosystems, supporting an enormous diversity of associated species, as well as being commercially valuable hardwoods and possessing inestimable cultural significance. Our study is applying dendroclimatological techniques to investigate the potential drivers of oak increment growth over the past century, and how knowledge of these may guide future adaptive management of oak. Amongst the possible drivers being considered are climatic extremes and norms, the eutrophication of forest soils, management interventions, and outbreaks of pests and diseases. Additionally we are investigating whether growing oak in a monoculture or as a plantation mixture with Scots pine (Pinus sylvestris L.) has an effect on its radial growth and resilience to climatic events. Tree height and diameter at breast height, fitted against yield table estimates, are being used as a second measure of tree productivity. Cores have been collected from 420 oak trees in four distinct regions, providing a gradient across the study region in edaphic, nutrient loading, and climatic conditions. Preliminary analyses suggest substantial resilience of the oaks to climatic events across the various gradients, and that the comparative incremental growth of oak in pure and mixed stands is more dependant upon the location than the species composition of the stand.

# Diversity and abundance of arthropods associated with Picea abies along altitudinal gradients

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The monitoring of species diversity and their turnover allow to observe and often to predict possible environmental changes as well as being key elements for measuring the biodiversity. This paper explores how the altitude affects the presence and abundance of arthropod species and how the population density of key species of pest insects change from one step to another along altitudinal gradients. The diversity and abundance of arthropods associated with Picea abies was studied along altitudinal gradients in the south-eastern Alps. Three different altitudinal gradients (Passo Mauria in Veneto, Pramosio and Tualis in Friuli Venezia Giulia) were chosen, and in each of them four steps (different altitudes) where identified. At each step one trap with generic lure (cross-vane for the study of biodiversity) and one with specific pheromone of Ips typographus were installed. The altitude difference between the steps was about 200 m. It was found that the number of arthropod species and individuals did not decrease with increasing altitude, as predicted considering a worsening of environmental conditions with increasing altitude. This can be explained with the fact that conditions are not limiting for spruce ecosystem at higher altitude. In our case, on the contrary, the number of individuals increased significantly with altitude. It was also shown that the population density of key species of pest insects changed from one step to another of the altitudinal gradient. In particular Ips typographus decreased with increasing altitude while Xyloterus lineatus increased. This can be explained with the availability of the breeding substrates and with possible interspecific competition.

# Seasonal fluctuation of Biscogniauxia nummularia, a latent pathogen of beech trees in Central Italy

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Disturbances, such those due to plant pathogens, shape forest ecosystems and influence their composition, structure and functional processes. Spreading of weak fungal parasites on forest trees growing on the border of their natural area is one of the expected consequences of global change. Climate change models predict extreme weather conditions characterized by long drought periods and by altered rainfall distribution. These factors may favour the spreading of pathogens toward new geographical localities and affect plant defenses. In Italy studies on Fagus sylvatica populations located near the southern limit of its natural distribution area showed that sanitary conditions of beech are strongly limited by drought. Biscogniauxia nummularia is a fungus known as endophyte of European beech, generally living in asymptomatic trees, but is also able to cause strip-cankers and wood decay on individuals stressed by drought. In the present work the latent phase of the fungus in symptomless host tissues was studied taking samples from apparently healthy beech trees growing in the Apennine Mountains. Twigs samples were collected in different seasons and used both for isolations and DNA extractions. Fungal quantification, detected after real time PCR assay (TaqMan chemistry), was higher in respect to isolation methods. The occurrence of B. nummularia as endophyte showed seasonal fluctuations and resulted scarce in the autumn and winter (5-20%) in respect to summer (40-100%). The higher amounts of B. nummularia during dry periods confirm the role of this fungus as bioindicator of beech forests in response to climatic change and particularly of drought stress.

# Vulnerability of European forests to climate change assessed by climatic gradients

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Altitudinal and latitudinal gradients provide a powerful tool for studying the potential impacts of climate change on forest dynamics. While climate has a large influence on tree performance, early developmental stages are expected to be more sensitive to climate change than adults. Because of that, we monitored seedling regeneration of eight dominant tree species of European forests (Abies alba, Acer pseudoplatanus, Fagus sylvatica, Picea abies, Pinus sylvestris, Quercus ilex, Q. petraea, and Sorbus aria) along five contrasting European regions (France, Spain, Germany, Sweden, and Poland), and at each region along elevation gradients, in the context of the EU-funded project BACCARA. In order to distinguish between climatic and other biotic and abiotic factors affecting seedling regeneration, we also recorded surrounding adults and environmental data such as vegetation cover or topography. The ongoing analyses using inverse modelling show an association between seedling density and elevation, highlighting the influence of climate on the regeneration patterns. The results of this study will enable us to improve the predictions about the effects of future climate change scenarios on the European forests.

# Impact of climate change on the regeneration potential of broadleaf species in Ireland

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Climate change potentially threatens the sustainability of some forest ecosystems in Ireland, especially natural and semi-natural forests and those that are managed to maintain biodiversity. The intention is that these forests would regenerate naturally, but climate change is a major threat to these forests. Seed germination is probably the most environmentally sensitive stage in the life cycle of a tree, yet this phase gets relatively little attention in the literature. Some tree species, such as rowan (*Sorbus aucuparia* L.) and blackthorn (*Prunus spinosa* L.) have a complex dormancy mechanism, so they may be particularly prone to climatic perturbations. Under natural conditions, rowan usually germinates in the spring following seed shedding whereas blackthorn germinates in the second spring after seed shedding. The effects of different combinations of warmth (ca 20 ºC) and chilling (3-5 ºC) treatments on the germination response of rowan and blackthorn seeds under controlled conditions were examined in this study. The results revealed that rowan seeds did not require warmth prior to the >110 days chilling needed to release dormancy, but short periods of warmth slightly reduced the amount of chilling needed. Blackthorn seeds required >40 days of warmth followed by >140 days chilling to release dormancy and additional warmth did not substitute for chilling. Climatic data were used to predict the impact of climate change on the germination response in both species. These data suggested that climate change is likely to reduce the regeneration potential of these species compared with other species, such as alder (*Alnus*) and birch (*Betula*) species. Alder and birch have less complex dormancy mechanisms and produce copious quantities of seed.

# Changes in climate: a possible trigger leading to the sudden die-off of Euphorbia ingens in South Africa

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The plant genus Euphorbia has a global distribution and includes more than 2100 species. South Africa has a rich diversity of Euphorbia species of which Euphorbia ingens is the largest in size. Huge numbers of E. ingens trees, in the Limpopo Province, have increasingly become diseased and have died during the last 10 years. Symptoms included grayish discoloration, rotting and browning of the succulent branches, white and yellow spots on succulent branches, blue stain and insect damage. During the course of 2007 and 2008, preliminary studies revealed various insects and fungi on symptomatic E. ingens, but with no clear evidence that they might be involved in tree mortality. In 2009, an in-depth study was launched to investigate the possibility that changes in climate could be a trigger leading to the sudden die-off of E. ingens. Four sites in the severely affected Limpopo Province and two sites in the North West Province where E. ingens was less affected were included in the study. Nine linear transects were established at each site and every tree in a transect was scored as alive or dead and as mature or juvenile. Beetle and moth damage, animal damage, fire damage and spots/ lesions on the succulent branches were scored as present or absent. Fruit quantity and gray discoloration of branches (a symptom of disease) were ranked by severity. Weather data from 1969–2008 were obtained for each site from local weather stations. As expected, trees in the Limpopo Province were more severely affected by disease and insect infestation and exhibited higher levels of mortality compared to trees in the North West Province. Analyses of weather data revealed changes in annual temperature and precipitation over the 40-year period analyzed, with greater upward trends in temperature and downward trends in precipitation in the Limpopo Province compared with the North West Province. Estimates of potential evapotranspiration and water balance indicated an increase in water demand while precipitation has remained the same or has decreased. The dramatic mortality of E. ingens that has been observed since about 2000 appears to be linked to increasing moisture deficits resulting in tree stress, which allow opportunistic fungal pathogens and insects to increase in severity, ultimately contributing to tree mortality.

# DISTURBANCES

# Soil biodiversity on forest ecosystems: assessing the impacts of environmental changes

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Forests are directly linked to climate change. They are impacted by global climate changes and at the same time they play a major role in mitigating it. Forests harbor an estimated two thirds of all terrestrial species and an important array of ecological processes. The ecological stability, resistance, resilience and adaptive capacities of forests depend strongly on their biodiversity (Thompson et al., 2009 ). Maintaining biodiversity in forest should promote their resilience to pressures and facilitate the adaptation of forests to expected climate change impacts. Soil biodiversity is directly operating a number of processes that support the capacity of soil to deliver ecosystemic services (C sequestration, infiltration, water depuration and water stock, organic matter turnover, biomass production). The assessment and survey of biodiversity changes in time is essential to detect long-term changes in the functioning of ecosystems and as such, needs to be integrated in monitoring programs of forest ecosystems health in relation to global changes and environment policies. A research study was conducted in the frame of the French network for the monitoring of forest ecosystems (RENECOFOR) in order to improve our understanding of how changes of the natural environment may influence soil biodiversity through the study of soil macro-invertebrate communities. A holistic approach taking into account physical, chemical and biological parameters was followed to characterize each forest and allowed grouping them depending on their similarities. Two synthetic indicators (GISQ (Velasquez et al., 2007 ) and IBQS (Ruiz et al., 2011 )) were applied to the forest environment in order to provide an assessment tool of forest ecosystem health for managers and deciders. Indicators provided reliable information on the status of the main soil compartments (organic matter level, soil structure, chemical and physical status as well as biodiversity) and allowed highlighting positive or negative impacts of environmental or human-induced changes. Thompson, I., Mackey, B., McNulty, S., Mosseler, A. (2009). Forest Resilience, Biodiversity, and Climate Change. A synthesis of the biodiversity/resilience/stability relationship in forest ecosystems. Secretariat of the Convention on Biological Diversity, Montreal. Technical Series no. 43, 67 pages. Velasquez, E., Lavelle, P., Andrade, M. (2007). GISQ, a multifunctional indicator of soil quality. Soil Biology and B iochemistry, 39: 3066-3080. Ruiz N., Mathieu J., Célini L., Rollard C., Hommay G., Iorio E., Lavelle P. (2011). IBQS a synthetic index of soil quality based on soil macro-invertebrate communities. Soil Biology & Biochemistry 43 (10) :2032-2045.

# Analysis of the sustainability of the Portuguese eucalyptus forest under different scenarios of wood and biomass demands, forest management and climate scenarios

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Production forest, in particular Eucalyptus globulus plantations, has gained importance for the Portuguese economy in the last decades. Recently, the increase of the pulp industry capacity leading to a higher wood demand, together with the biomass for energy demand combined with a high incidence of forest fires, jeopardize the sustainability of eucalyptus forests in the country. Climate change, particularly spring and summer drought, has also impacted the stocks due to an increase in mortality which might be complemented by a decrease in growth. The use of process-based models to make projections of production forest development is therefore gaining relevance. 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. In Portugal the 3PG model, a simple process-based stand model requiring few parameter values and only readily available data as inputs has been parameterized for growth simulation in eucalyptus plantations. The 3PG model includes modules for biomass production, biomass allocation, stem mortality, soil water balance and information for managers (stand information). Some modifications have been made in the equations used to predict stand volume and basal area. Several equations/modules were added in order to obtain detailed outputs similar to the ones produced by the growth and yield model that is operationally used in the country. The resulting model, designated by 3PG-out+, has been implemented in a regional simulator – SIMPLOT – that uses data from the Portuguese National Inventory to make long-term projections of the eucalyptus forest – area and growing stock by one-year age class – taking into account different scenarios of wood demand, biomass demand, annual rate of afforestation (wood and bio-energy plantations) and deforestation, and annual area of burned stands. The substitution of the traditional model GLOBULUS by the 3PG-out+ model allows taking also into account different climate scenarios. The implementation of 3PG-out+ into the regional simulator SIMPLOT will be described and the evolution of the Portuguese eucalyptus plantations under different scenarios will be analysed. Most of the scenarios show the consequences of a serious overharvesting that is occurring in the country. The simulator, if combined with optimization techniques, can be used to estimate the annual needs of wood imports or to estimate the effort that will be needed in new plantations in order to be able to sustain the wood and biomass demands that are expected.

## Evaluation of drought stress impact on transpiration losses in Norway spruce (Picea abies (L.) Karst) in Biosphere Reserve Poľana

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Norway spruce is one of the most significant European tree species which suffers from various health and growth problems appearing in the last decades due to climate change. The main problem in Slovakia nowadays is large-scale dieback of spruce forests. The aim of the presented contribution is to compare the potential transpiration, represented by transpiration of trees with a sufficient supply of available soil water (irrigated during the experimental period) with the transpitation of trees suffered under the drought stress and then finding out the level of the soil moisture influence to transpiration of the spruce stands. Experimental plots were established in the two growth stages of spruce stands namely; the "pole stage" and the "maturing stand", in spruce stands localized out of the original area of the spruce distribution in Slovakia in Biosphere Reserve Poľana. Values of sap-flow intensity were measured continually during the whole days by using of THB method in 24 sample trees in course of growing season 2009. In order to investigate the drought impact on physiological characteristics of spruce, six out of twelve sample trees from each plot were left in conditions of drought and the other six were irrigated due to generation suitable conditions for running of the physiological and growth processes. Cumulative deficit of transpiration (mm.ha–1) was calculated for the days when transpiration between variants was statistically significant. Twenty-one days like that were occurred in the "pole stage". Mean transpiration of drought stressed individuals dropped in course of twenty-one days to 23 % of potential transpiration. For one hectare of stand (where mean sample tree was 55.2 cm in breast height diameter and 0.8 stand density) it meant 35.93 mm.ha–1 of transpiration losses. Eighteen days of statistically significant differences between variants were found out in "maturing stand", where transpiration was decreased only to 48 % of potential. The transpiration losses for one hectare of stand were 7.35 mm.ha–1 (d.b.h. – 125.5 cm, stand density – 0.5). Also water potential of needles of nonirrigated individuals significantly decreased – the lowest average value was approximately –1.4 MPa. These values indicate moderate drought stress. In the "pole stage" we found a statistical significant difference between variants about the value of volume soil moisture 10.38–13.73%, and in the "maturing stand" 15.58–18.89 %. The reason of this difference we could find in different location of plots, their soil quality and conditions of water outflow.

**Assessing climate change impacts and multiple disturbances in the Island Forests of Saskatchewan, Canada using LANDIS-II**

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A climate change vulnerability and risk assessment was carried out for the Island Forests of central Saskatchewan Canada using the process based landscape model LANDIS-II. These Island Forests are of particular concern because they lie at the southern edge of the boreal forest in central Canada, exist in a marginal semi-arid climate on drought-prone soils, and are spatially isolated forest ecosystems, making them highly vulnerable to climatic extremes and climate change. This area is predicted to be one of the first areas to be affected by climate change in the southern boreal forest and is therefore, a good place to start evaluating potential vulnerabilities and adaptation options for sustainable forest management. Multiple sources of vulnerability were considered with regards to climate change including: drought, pests, fire, changes in forest productivity, potential shifts in species, and regeneration potential of the major commercial tree species [jack pine (Pinus banksiana), trembling aspen (Populus tremuloides) and white and black spruce (Picea glauca and P. mariana, respectively)] and other secondary species. LANDIS-II is one of the few models that can simulate broad scale landscape dynamics, while simultaneously including succession, natural disturbances (fire, insects, disease), seed dispersal, forest management, and climate change effects. LANDIS-II also explicitly incorporates the interacting effects of disturbances on subsequent forest composition, e.g. the interaction between insect outbreaks and fires. The flexibility of this model allows it to be used to answer a variety of questions regarding vulnerability, risk, adaptation options and long term forest management at a landscape scale which is relevant to forest managers. Following the vulnerability assessment, a risk assessment was conducted to characterize the severity of consequences and help with the next phase of identifying potential adaption options. An adaptation strategy was developed for the study region based on the foregoing vulnerability assessment and risk analyses. The following elements were addressed: identification of priorities for adaptation, opportunities for mainstreaming adaptation, conducting policy audits in which forest management and related policy is reviewed, and documenting best management practices under climate change.

# How does climate change affect forest growth and damages – Climforisk, EU Life + project

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Climate has direct influence on forest carbon and water balances, but it also influences forest damages. Some pests/pathogens can cause wide spread forest damages, with severe implication of forest carbon balances. Populations of these pests can grow enormously when climate and other factors turn favourable. For example, the most important pine defoliators (e.g., Neodiprion sertifer; Diprion pini, Bupalus piniarius, Panolis flammea) benefit from drought and warmth. In turn, there is evidence that the outbreaks of N. sertifer are locally limited by extreme minimum winter temperatures. Forest inventory of Finland has collected an enormous body of data with tens of thousands of sample plots measured, which can be merged to other sources of data on forests, such as remote sensing images and digital soil map. Merging these data sources to models and climate data offers a possibility to construct high resolution estimates of forest carbon and water balances for the whole country. The occurrence of biotic damages in Finnish forests, on the other hand, has been monitored for several years using permanent sample plots. Using these data it is possible to identify climatic, edaphic, structural and spatial factors that predispose forests to damaging pests/pathogens. The aims of our project are to i) merge several existing, but to date separate, forest data sources together, ii) use models to predict how carbon sinks and sources are distributed with Finland, iii) investigate factors predisposing forests to damages caused by most important pests/pathogens. Our project will provide background information for designing adaptation measures to climate change. Results of the project will be disseminated to the public and officials through a web portal launched at the end of project. Climforisk, 2011–2014 LIFE09 ENV/FI/000571 Climate change induced drought effects on forest growth and vulnerability, www.metla.fi/climforisk.

# Is the interaction between waterlogging and drought responsible for oak decline in Allier, central France?

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In Allier, central France, oak forests cover more than 60 000 ha and represent an annual wood stock of 11 million m3. This is more than 8% of the annual French production and especially it is about 10% of the annual French production of stavewood, a premium quality wood used for manufacturing barrels worldwide. However, for several years, an oak decline has been observed with economic, ecological and cultural consequences for this territory. In the context of climate change, the models of climatologists announce an increase in the heterogeneity of annual rainfall distribution. This means an increase of winter-spring waterlogging and marked summer droughts. Both of these events are estimated to have a strong impact on the oak decline by limiting tree growth and/or inducting a deficit of carbon reserves that may limit future resistance to stress, especially related to winter frosts. Therefore, our objectives were i) from a scientific point of view, to better understand the role of waterlogging, drought and their interactions on oak decline; and ii) from a practical point of view, to provide manager tools for estimate oak decline risk according to site and climate characteristics. We worked with two main oak species: Quercus robur and Quercus petraea, in order to estimate the specific vulnerability of each species. In the literature Quercus robur is supposed to better resistant to waterlogging and on the contrary Quercus petraea seams to be better drought resistant. Little is known about the effects of alternation of these two stresses on the health of both oak species. Microclimate (light, rainfall, soil and air temperatures, air humidity), soil water balance (volumetric soil water content measured by TDR sensor, water table depth), tree transpiration (estimated by sap fluxes), winter frost resistance (LT50: thermal lyses by electrolyte leakage method) and root and stem growth (rhizotrons, automatic micro-dendrometers) are recorded on two systems: * An experimental one with two years old oaks in containers in the laboratory. Responses of trees are recorded after different controlled alternating conditions of waterlogging and drought, relative to time of application and intensity. * In the field, in eighty years old stands selected on hydromorphic soils in forest in Allier. Because of the high clay content, this characteristic poor soil allow to observe effect of a natural alternation from high levels of superficial water table in winter-spring to marked droughts in summer. Our first results on roots and trunk growth will be presented and discuss according to water budget and climate records. The specificity of both species will be studied, depending on the intensity of the water stress to which trees were submitted.

# A Bayesian Belief Network approach to assess the impacts of disturbance agents under conditions of climate change

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In mountain forests of Central Europe storm and snow breakage as well as bark beetles and forest fire are the prevailing major disturbances. Under conditions of climate change disturbance regimes are likely to intensify and thus may severely impact on the provision of forest ecosystem goods and services. The complex interrelatedness between climate, disturbance agents and forest management increases the need for an integrative approach explicitly addressing the multiple interactions between environmental changes, forest management and disturbance agents to support forest resource managers. Empirical data providing a comprehensive coverage are rare, thus making development of statistical models particularly problematic. However, the complex causal relationships between disturbance agents and predisposing site and stand-related characteristics are well suited for knowledge-based expert models. Bayesian belief networks (BBNs) are a kind of probabilistic graphical model that has become very popular to practitioners and scientists mainly due to the powerful probability theory involved, which makes BBNs suitable to deal with a wide range of environmental problems. Risk and uncertainty can be considered explicitly and the implications tested analytically. In this contribution we present the development of a dynamic Bayesian Network (DBN) and its implementation with the HUGIN software package to address the interaction of disturbance agents mentioned above. A three stage iterative process with stakeholder participation was used to develop the Bayesian Network within the frame of MOTIVE. The group of participants varied in the stages of the modelling process. A core team, consisting of one technical expert and two domain experts was responsible for the entire modelling process as well as for the first prototype of the network structure, including nodes and relationships. A top-level causal network, which links biotic and abiotic factors, was further decomposed to sub level networks. For each disturbance agent a sub network describes linkages of site and stand related attributes of storm and snow breakage, fire and bark beetle infestations building on cause-effect relationships. To add the time dimension to our model examination sequences which are a characteristic of DBNs were used. Stakeholder participation including a group of experts from different related subject areas was used in model verification and validation. Furthermore, a range of practitioners were consulted to increase model acceptance and to ensure that results were matching expected enduser requirements. We demonstrate that BBNs can be used to transfer expert knowledge from science to practise and contribute to improved problem understanding of non-expert decision makers.

# Dieback symptoms in Pinus sylvestris L. in Pieria Mountains

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The scots pine in Greece forms a forest of approximately 1.000 hectares in Pieria Mountains. This individual forest is the southernmost limit of this species distribution across Europe (N 40° 14' 30'' E 24° 17' 00''). It extends to elevation from 1.400 – 1.800 m a.s.l and in the two main aspects of the mountains, East, (Ritini compartment) and West, (Katafigio compartment). Analysis of the climatic data of the period 1957-2009 revealed that, annual precipitation reduced from 1020 mm in fifties to 760 mm in 2009, mean and maximum temperature increased from 9.5 to 11.1 °C and from 20.3 to 27.4 °C respectively. Generally, the prevailed climatic conditions posed the scots pine trees under intense stress for considerably long time which leads to progressive deterioration of the stands. The differences in the forest structure on both aspects are significant. The East aspects (facing to the sea) comprised with widely spaced old trees, the canopy cover in many sites doesn't overcome 0.5 and due to previous livestock grazing there is no natural regeneration. The West aspects are covered by dense young forest while in forest sections with older trees there is natural regeneration. Ten sample plots one tenth of the hectare each were established and analyzed. The mean standing volume was 380m3 Ha-1, basal area 48.8 m2 Ha-1, 380 stems Ha-1, mean dbh and tree Height 35.4 cm and 17.2 m respectively. The coarse woody debris was relatively high for a managed forest ranging from 23.3 m3 Ha-1 or 6.1% for snags and 45.9 m3 Ha-1 or 12.1% for lying wood, totally the dead to standing wood ratio was 18.2%. Thirty per cent of the standing trees have had low vitality. Twenty seven percent exhibited malformations like forked, broken tops, leaned stems etc. The shrubs layer is represented by scots pine with 67 stems Ha-1, fir with 40 stems Ha-1 and beech with 28 stems Ha-1. In regeneration layer, Scots pine exhibits 2696 seedlings and saplings Ha-1 while fir and beech 560 and 11 saplings Ha-1 respectively. The scots pine stands in Pieria Mountains is considered critical, the trees are very old, unhealthy and 30% of them have been attacked by the fungus Peridermium pini. In the region today there is little pressure from livestock grazing. Previously, the pressure was much heavier affecting scots pine natural regeneration impossible and ecosystem degradation. It is difficult to separate this anthropogenic impact from climate change and to determine the extent affected the stress and degradation of the ecosystem. In the last decade only dead scots pine trees are being cut. Despite all this, the snags and lying dead wood in all plots was high. This phenomenon of dead trees leads progressively to lower number of stems and reduced canopy cover along with the lack of natural regeneration can transform the scots pine stands into partially forested meadows.

# RECENT AND FUTURE TRENDS IN FOREST PRODUCTIVITY AND SPECIES DISTRIBUTION

# Climate Change and Forestry in Rhineland-Palatinate (Southwest-Germany) – an assessment of regional impacts

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Impacts of climate change concern all environmental fields and all types of land use, whereby the effects on the regional level will be different and specific. To assess effects, risks and chances climate change can cause in Rhineland-Palatinate and which possible adaptation options can be developed, was the aim of the project KlimLandRP ("Climate and Landscape Change in Rhineland-Palatinate"). Rhineland-Palatinate is the German's federal state with the highest share of forested area (42 %) and has plenty of characteristic forest landscapes as Palatinate Forest, Hunsrück and Westerwald. Based on different IPCC-Emission scenarios, different regional climate models, and two time stages (until 2050 and until 2100), insights about the expected regional impacts of climate change on the Rhineland-Palatinate woodland could be acquired. Therewith, a corridor of managing options was delineated e.g. on the tree species selection. In the context of the issue climate change / forest use also the social-empiric perspective was concerned through dialog with the regional stakeholders. In general, the methodical approach consists of an empirical and a deductive analysis of the climatic suitability of the main tree species under changing stand conditions, through a GIS-based analysis of Rhineland-Palatinate's forested areas. More specifically, the method is made up of the integration of several approaches (self developed or published). Used approaches are e.g. bio-climatic envelopes for the main tree species under different climate parameter combinations, climatic suitability mapping for the main tree species, climate sensitive forest growth simulation of the most relevant forest types and forest landscapes, water budget simulation for typical forest sites as well as diverse case studies on different spatial resolutions. In general, the different results lead to consistent insights: on the one hand in several regions the forestry production risk increases, on the other hand some tree species would be able to profit, e.g. due to the warming tendency in today's cool regions. The presentation provides an overview of the applied methods and it main results for the time stages 2050 and 2100 under different IPCC-Emission scenarios. Furthermore, an integrative interpretation of the several results is stated. This study is an example on assessing climate change impacts on the forest land use on a landscape scale.

# Ectomycorrhizal community along an altitudinal gradient in Quercus ilex Mediterranean forests

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In the Mediterranean basin, Holm oak (Quercus ilex L.) is one of the most characteristic and abundant forest trees. In particular, the oldest Holm oak forests are present in Sardinia, where they play an important role for ecology, in particular for the preservation of the biodiversity. As the effect of global change on these forest is well known to be mediated by the organism within forests, biological diversity is key to understanding forest response to global change. It is the responses of individual organisms in their communities that begin the cascade of ecological processes. An important microbial-plant symbiosis that should receive more attention regarding potential climate change response and ecological effects is that of ectomycorrhizae. Therefore, the main goals of this study were to investigate which ectomycorrhizal community are associated to the oldest Q. ilex forests in the Mediterranean basin and to verify if the altitude significantly affect root apex vitality and ectomycorrhization. During 2010, roots samples belonging to 3 comparable Holm oak sites in Sardinia (Italy) were studied. In every site, 3 comparable couples of plots (stand age, soil, exposition) were chosen according to the elevation: 200, 600, 1000 m asl. In every plot 5 coeval plants were chosen; from every plant 4 soil cores were collected along the 4 cardinal directions. From every core, 10 rootlets were selected. The vitality and ectomycorrhization of root tips were studied (in total, 3600 ectomycorrhizal root tips). The 56 ectomycorrhizae detected were classified according to morphological, anatomical and molecular investigations. Kruskal-Wallis test was performed to test significant differences among vitality and ectomycorrhization. Multivariate statistical analyses (DCA and CCA) were performed to investigate potential relations among environmental variables (sites, cardinal direction of sampling, altitude) and species abundance of ectomycorrhizae. The results showed that the altitude doesn’t significantly affect vitality and ectomycorrhization of root tips. Vice versa, the environmental variables that resulted as significantly explaining the ectomycorrhizal variability are altitude and South sampling point. These variables could be associated to an increase of xeric and drought environmental condition at soil level. Considering the importance of ectomycorrhizal network and the role of ectomycorrhizal species in mediation of resource distribution among trees, physiological aspects related to the enzymatic properties of species associate to drought should be deepened. Future researches focused on Holm oak forests along altitudinal gradient in different sites and seasons are needed, also to contribute to the assessment and management forest strategies to sustain Mediterranean forest ecosystems.

## Climate change and phyllosphere fungal communities: a study on a European beech (Fagus sylvatica L.) altitudinal gradient

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The effect of climate on the fungal assemblage inhabiting the phyllosphere of the European beech (Fagus sylvativa L.) was assessed along a 1000 meters altitudinal gradient in the French Pyrénées Mountains using tag-encoded 454 pyrosequencing. The gradient was sampled two times over two consecutive years. Fungal assemblage composition significantly followed the altitudinal gradient and correlates mainly with the maximum temperature recorded since bud burst and with the amount of hours above dew point experienced during a month before sampling. Among the abundant species, we identified two beech beech pathogens, Mycosphaerella punctiformis and Phyllactinia guttata which may shift upward under climate change, and thus increase selection pressures on beech populations in the upper part of the Pyrenees. Since phyllosphere fungi are considered as early decomposers of the leaf litter, climate change may also impact geochemical cycle, through a shift in fungal assemblages recycling organic matter.

## Changements climatiques et conséquences en Kroumirie; nouveau facteur de dépérissement ?

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Les changements climatiques sont devenus un sujet de préoccupation majeure depuis quelques décennies. Les dérives climatiques observées sont une source d'inquiétude croissante puisqu'elles menacent d'affecter considérablement le mode de vie des populations aussi bien végétale qu'animale. Divers signaux biologiques montrent que ces perturbations climatiques sont déjà bien perceptibles. Cependant, peu d'études concernant la réaction des peuplements forestiers aux changements climatiques sont élaborées surtout en Afrique du nord où certaines espèces se trouvent en limite méridionale de leur aire de distribution. Les forêts de chênes lièges en Kroumirie font l'objet d'une diversité écologique importante aussi bien sur le plan des espèces, des faciès ou des paysages. Malheureusement, nous assistons depuis plusieurs années à des dégradations continuelles de cette subéraie qui engendrent vraisemblablement un déséquilibre écologique et social. Parmi les facteurs à l'origine du dépérissement des forêts de la Kroumirie : les changements climatiques caractéristiques de ces dernières années avec des épisodes de sécheresse estivale marquées. On propose dans ce travail de déceler les éventuels impacts de cette contrainte climatique sur la croissance de différentes populations de chênes lièges de la Subéraie Occidentale Tunisienne. Cela a nécessité l'application de plusieurs approches: une analyse de la climatologie régionale sur le 20ième siècle et ses prévisions pour le 21ième siècle; suivie d'une mise en évidence de la relation entre les conditions de milieu (altitude et climat) et le fonctionnement des populations de chêne liège à petite et grande échelle (paramètres biométrique et structuraux de feuillages ; croissance radiale). Les résultats laissent penser à une prépondérance de l'influence du climat sur la composition des futurs paysages de la Kroumirie. Ils semblent réalistes puisque le climat futur prédit par le modèle ARPEGE sera plus sec et plus chaud que le climat actuel. L'analyse des paramètres biométriques (DBH, hauteur..) et structuraux de feuillages (LMA) ainsi que les différentes fonctions de réponse, exprimant les effets relatifs séparées des relations cernes-climat, mettent en évidence l'étroite liaison entre la croissance et le climat chez le chêne liège en Tunisie. En effet, la sensibilité du chêne liège aux facteurs climatiques semble se décliner en fonction de sa situation géographique liée à l'influence de la continentalité qui entraîne une sensibilité accrue au facteur climatique.

## A dendroecological reconstruction of pedunculate oak growth on salt affected soil under climate change

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Common oak (Quercus robur L.) is spread through greater part of Europe, and it is also dominant tree species in natural forests in the Pannonian Basin with continental climate. In Pannonian Basin common oak the best site conditions for grown are in hydrophilic forests Alno - Quercion roboris. In addition, as the main species oak occurs in community Aceri tatarico – Quercion roboris on loess plateaus and occupying higher parts of the alluvial terrace. In the community of Aceri tatarico – Quercion roboris on the salt affected soil type the most common community are Festuco pseudoovinae - Quercetum roboris. The aim of this study was to analyze the dynamics of growth of order of salt affected soil types in the period from 1960 to 2007 depending on climate conditions during this period. It follows that the idea of work defining the dynamics of growth in less favorable habitat conditions for the cultivation of oak, with an assessment of further breeding in the changed climate conditions. The research was carried on the I) chernozem on sandy loess; II) chernozem - solonetz and III) solonetz. Observed climate changes are reflected in the increase in average annual air temperature. The data suggest that the increase of average annual air temperature in the period 1998-2008 compared to 1960-1991 was higher for 1°C. Reduction of rainfall was recorded for the period December, January and February and for the month of May. These deficits of rainfall with an increase of average air temperature in the vegetation period (July 1.2°C and 1.7°C in August) leading to longer and more frequent dry periods, and thus to all the unfavorable conditions for the growth of oak trees. Maximum of annual volume increment on different soil type was determined in different age. The earliest was on, at the latest on the chernozem on sandy loess. The greatest decline in growth was determined on the chernozem on sandy loess. The above phenomenon is related to the drought years in the period from 2000 to 2007. This leads to the conclusion that the trend of climate change can be a limiting factor for the survival of forest vegetation in this site conditions. Acknowledgement: This study is results of project III 43002 financed by Ministry of Science and Technological Development of Republic Serbia. Key words: common oak, climate change, salt affected soil.

## Low frequency signals in tree-ring series of central European mountain Norway spruce closed canopy forest

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The knowledge about past nature variations is highly needed for understanding the present and anticipation the future. Tree rings are important proxies that could be used for a reconstruction of past environments. Describing the long term variability of such environments is a big scientific issue at this time. The tree-ring record consists of several signals and therefore the aim is to filter out noise and extract the signal. Dendrochronologists often used those stands that are naturally (as expected) without noise growing on extreme sites. But past environmental variations of forest growing on average sites is important to analyze. This is the aim of this study. Trying to describe different low frequency signals in tree rings from central European mountain Norway spruce closed canopy forest. Absolute growth of a tree is affected by internal plant mechanisms (such as ageing, gene, microsite...), weather and site (light, temperature, precipitation, nutrition – deposition of N and C, acidity...) and competition (releases and suppressions caused by stand dynamics). The age effect could be effectively filtered out by a few methods (the RCS-method was successfully used, for example). Using this method, the effect of competition is often also filter out in shade intolerant species. But using dense forests were trees sustain longer period of suppression we have realized that the effect of age and competition differ. The low frequency signal in our resulting chronology could be explained by competition dynamics of the stands. If we are interested in climate dynamics we have to remove the effect of competition. We tested few possibilities: modification of RCS-method, intervention analysis and analysis of trend synchronisations. There raised the need of repetition in reconstructing past climate environments to get reliable results. The statistical characteristics of the set of samples (from which the calculation of the average curve is done) are important. We tested the relation of resulted chronology with the instrumental climate, acidification and deposition data.

## Future trends of selected important forest tree species of Bangladesh considering climate change using GIS

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Economically important forest tree species were purposively selected and experimented to identify their climatic and edaphic suitability for future in Bangladesh. Maps were prepared to show suitability for each species throughout Bangladesh. There would be a decrease in geographical area distribution of some species within the year 2100 than present condition. The area of Anisoptera scaphula would loss its area by 18.75 percent. Like this species; areas of Hopea odorata, Artocarpus chaplasha, Swietenia mahagony, Albizia lebbeck, Albizia procera, Lagerstroemia speciosa, Cassia fistula, Terminalia belerica and Heritiera fomes all decrease significantly by 8, 69, 22, 40, 19, 32, 31, 100 and 100 percent respectively. This indicates that these species may experience habitat loss in future. Moreover, some of the exotic forest tree species like Acacia auriculiformis and Eucalyptus camaldulensis decrease by 12 and 15 percent respectively. There are some species Shorea robusta, Terminalia arjuna, Sonneratia apetala, Tectona grandis and Leucaena leucocephala would be increased by 34, 25, 110, 22 and 45 percent respectively. Analyzing the species maps it is found that for most of the species their geographical distribution slightly shifts from Western to Eastern part of the country. This may be due to altitudinal raise from western to eastern part of the country. Maps also depict that some forest tree species like Terminalia belerica and Heritiera fomes would be extinct considering changing climate i.e. in the year 2100. Thus, it may be forecasted that there might be a change in species distribution of forest with 4°C temperature increase and 100 cm precipitation change by 2100. Key words Forest tree distribution, climate change, GIS, tree migration.

# Dynamic of coppice oak stands under changing climate conditions

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This paper represents the case study on coppice forests developed for MOTIVE Project. This case study looks into traditional coppice forest management versus transformation into high stands and restoration of the native tree species under man made conifer plantations. Development of coppice stands is studied with dynamic forest ecosystem model (PICUS).

# Comparative use of SAR and Lidar sensors for the deduction of structural forest attributes addressing the discrimination of different forest stand characters

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Like most other European forested landscapes, within the last centuries the Hunsrück low mountain range region was subject to forestry activities targeting mostly at a maximisation of timber harvesting. At our case study site, situated at the Idarwald, Western Germany (49°40'N, 7°10'E), the dominant tree species are Norway spruce, beech, oak and Douglas fir. Particularly for the boggy and waterlogging areas of the Idarwald ridge the contrast between native forest communities and the recent commercial forests was very sharp. But within the last decades two main effects caused significant changes within these largely monostructured stands. One effect is mostly natural: following two events of gale-force winds in 1990 and 2003 many of the badly adapted spruce stands have been trashed, especially on the soils prone to water logging. Afterwards more structured and mixed natural succession stands got the chance to take hold of these sites. The second effect is anthropogenic: as a consequence of the reorientation of forestry objectives new sustainable forest management strategies now also contain multistage stand structures, species richness and site adaptation of forest stands. So nowadays the Idarwald forest consists of a patchwork of different stands from old commercial forests to stands within alteration and different stages of succession. Our approach is to allocate typical combinations of structural forest attributes to all these different forest stand characters. As manual survey methods are time-consuming and costly, remote sensing methods are recommended for larger regions. For mapping structural forest attributes, only active sensors like microwave and Lidar systems are usable because of their ability to penetrate into the canopy and provide information from stand interiors. Within this group of sensors each has different advantages and disadvantages in the acquisition of key attributes like main crown height, canopy closure or detection of undergrowth vegetation. Hence within our study, conducted within the context of the project ForeStClim, co-funded by the EU, we compare the results concerning the determination of a range of structural forest variables for an airborne Lidar instrument, operating in a full wave modus and for a dataset assembled from several spaceborne SAR operating on X-, C-, and L-Band. Both systems facilitate the segmentation into different forest types based on structural attributes but for a concluding assessment not only the accuracy of parameter determination has to be taken in account but also factors like acquisition costs and repeatability.

## How will climate change affect tree distribution and management? Modelling the response of sugar maple in Quebec

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Rapid anthropogenic climate change is already affecting species distribution and ecosystem functioning worldwide. We applied niche-based models to analyse the impact of climate change on the spatial distribution of 117 tree species in eastern North America, with a focus on Quebec (Canada). We report on the potential response of sugar maple (Acer saccharum), a species of ecological, economic, and cultural importance in Canada, to illustrate the importance of regionalizing the response of species and quantifying uncertainty to inform management. The current distribution of sugar maple was assessed as a function of climatic (mean annual temperature, total annual precipitations and useful precipitations; observed data 1961-90, 30-year mean), topographic (slope and altitude) and edaphic characteristics (origin and depth of the soil deposit, drainage class) using eight state-of-the-art statistical modelling techniques. Data were randomly partitioned into calibration (70%) and evaluation (30%) datasets; this data splitting procedure was replicated 10 times. Calibrated models were then used to generate projections of future potential distributions under each of seven different GCM x SRES combinations selected from a clustering analysis of 70 climate scenarios for 2041-70 and 2071-2100. A weighted average consensus method was used to combine the probability of occurrence of each species predicted by the 80 current and the 560 future different projections. Uncertainty was taken into account by mapping the future distribution of suitable conditions at the regional (Quebec) and sub-regional (bioclimatic regions) scale using a threshold of at least 60% of agreement among projections to attribute an occurrence value (0-1) to a 400km2 cell. Cells for which > 60% of the projections disagreed were excluded from interpretation. The percentage of the range which showed different response scenarios (stability, gain, loss, etc.) compared to the reference period (1961-1990) was compiled at the regional and sub-regional scales for the species. Results emphasize the potential for very significant impacts of climate warming on sugar maple. These impacts vary depending on the sub-regions. At the Quebec scale, 12% of the cells were excluded because of uncertainty. Although only 1% of the Quebec range was considered lost under a scenario of full migration, the loss was as high as 40% in the current most productive sub-regions for the species. Conditions become climatically suitable in no less than 57% of the study area in Quebec. The impacts of these considerable spatial changes on the conservation, management, and economic value of sugar maple are discussed.

# ECOSYSTEM RESILIENCE

# Dynamic CGE-model with heterogeneous forest biomass: Applications to climate policy

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This study introduces a framework for modeling a renewable forest biomass stock interacting with economic sectors in a competitive economy. The equilibrium is formulated as a mixed complementary problem (which explicitly represents weak inequalities and complementarity among decision variables and equilibrium conditions). The complementarity format permits detailed modeling of the growth and harvest of a biomass stock together with a second-best characterization of the overall economy. A stylized numerical example of a dynamic computable general equilibrium model is presented with illustrative applications of the model for gauging effects of environmental subsidies and taxes intended to promote increases carbon storage in forest biomass.

# Radziejowa in the Carpathians - an example of forest biodiversity in altitudinally diversified landscape

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Dr. Hilszczanski JACEK - Poland
Dr. Ambrozy SLAWOMIR - Poland

A set of experimental plots covering forest diversity in altitudinal gradient (500-1100 m a.s.l.), simulating possible climate change, was set up in Radziejowa Massif in the Carpathians within BACCARA project. The forest biodiversity was investigated on several functional levels: forest tree species, ground vegetation, herbivory insects and their natural enemies. Possible effects of chaging climate on these components of forest ecosystems are proposed based on presented results.

# Estimation of net primary production based on model biome-bgc and climate change scenarios

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Atmospheric CO2 and mean annual temperature have increased in the last decades. There is a great need to better understand the response of the different forest species to climate changes. Experimental climate manipulation studies are one of the approaches that give a better understanding of the effects of climate change in forests and help in clarifying this subject; however, these experiments are expensive and time consuming. Another approach is to use ecosystem process models to examine the effects of different climates on net primary production (NPP). The productivity of an ecosystem is an essential parameter to evaluate the forest development and can be used in the species selection and other management decisions. In this study, the NPP was estimated applying the model BIOME-BGC, an ecosystem process model, using measured site and species-specific parameters for Pinus pinaster, Quercus pyrenaica, Castanea sativa and Pseudotsuga menziesii, in the northeastern Portugal, and to assess the effects of potential climate change and atmospheric CO2 concentration increase, on the forest productivity of these species. The tested climate change scenario was maximum and minimum temperature plus 3.0 ºC, coherent with the projections of most GCM's, a decrease in the annual precipitation by up to 15%, in agreement with the SIAM Project. The 2 X CO2 scenario was based on the reference value of 280 ppmv. The simulated results indicate that NPP showed relatively little response when precipitation alone was taken into account, only the P. menziesii forests showed a significant increase in NPP (10.8%). The effects of temperature alone were positive for evergreen needle-leaf forests. With changes in both temperature and precipitation, only the P. menziesii forests showed a significant increase (16.6%). The predicted NPP increased significantly for all species when doubled atmospheric CO2 concentration was taken into account with increases of 27.5% for Q. pyrenaica and of 50.1% for P. menziesii. These results, when compared to the other climate change scenarios, indicate that the NPP shows a positive response to the doubled atmospheric CO2 concentration alone and is the most important climate variable for the deciduous broad-leaf. For all species the higher increase in NPP is observed with the doubled atmospheric CO2 concentration and the behaviour of the NPP through the species is similar in the scenarios without changes in atmospheric CO2 concentration compared to the scenarios with doubled atmospheric CO2 concentration.

# Erosion mitigation services of new forests planted for carbon credits under intensification of extreme rainfall events

Ms Barbara HOCK - SCION - New Zealand
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New Zealand's adoption of an Emissions Trading Scheme has raised the interest in tree plantings on land marginal for other land uses, in order to capitalise on carbon credits. Nationally available spatial data sets were used to identify potential areas for these plantings. The land needed to match the eligibility criteria for qualifying as carbon credits (not replacing existing forests), avoid biodiversity losses, and be suitable for tree growth. The land classes with lower versatility for agricultural use were targeted to avoid displacing more intensive food productivity. Three potential afforestation scenarios were developed with areas of ca. 0.7 million ha, 1.2 million ha and 2.9 million ha. The afforestation scenarios also lead to the reduction of the risk of soil loss, and hence productivity loss and downhill/downstream effects, for areas prone to erosion. This is not only a benefit under current climate conditions, but also under climate change which is expected to increase the risk of erosion in areas with predicted rainfall increases. Erosion and sedimentation risks are especially heightened during intensive rainfall events, which are similarly predicted to increase in intensity under climate change. The effect of extreme rainfall events was investigated for all the marginal lands across New Zealand and compared to effects under each afforestation scenario. Extreme rainfall data for both current and future climate were investigated. Land vulnerable to extreme rainfall events was derived by combining areas with an inherent susceptibility to erosion with high intensity rainfall data (rainfall greater than 300mm within 72 hours). These areas of high intensity rainfall are for current climate conditions and for a climate change scenario of 2°C warming. Nationwide, 7.6% (1.0m ha) of farmland was found to be erosion prone and vulnerable to extreme rainfall events. Under the 2°C temperature increase, this area increases to 10.3% (1.4m ha). Afforestation of, for example, 1.2 million ha would reduce the area of vulnerable farmland to 5.5% (0.7m ha) under current climate, with a similar effect under the worming scenario. Vulnerable lands are more common in some regions compared to others; these lands and their relative risk levels are located on maps. The scenarios were developed into accessible views to facilitate the demonstration of the erosion services of planted trees to future-proof lands for potential climate change.

# Effects of super-absorbent and irrigation on the growth of pistachio seedlings (Pistacia atlantica), NW Iran.

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Climate change, particularly climate warming, is considered as an important factor to increase water demand in plant. On the other side, water resource deficit is a big problem worldwide. So they cause seedlings mortality increases aggregately in natural forests and plantation areas. Irrigation in afforestation area plays an important role relating seedlings viability especially in arid or semi-arid lands. Furthermore, irrigation involves expenses and difficulties. Pistachio is planted mostly in bare land of Zagros forest (W Iran). Lack or insufficient irrigation causes rising mortality of pistachio seedlings. So, it is crucial to look for alternative methods that can not only decrease water consumption but they can increase soil moisture and seedling maintenance over a growing season. A new technique is using super-absorbent. We have used factorial experiment based on completely randomized design to examine the effect of applied super-absorbent on the growth of pistachio seedling. The treatments applied are: 1-super-absorbent in 3 levels (0, 50 and 100 gr), 2-irrigiation in 2 levels (5 and 10 lit) and 3-period in 3 levels (10, 20 and 30 days). Overall 18 treatments with 3 replications in each and 3 individuals in each replication were examined. Furthermore, 9 individuals were considered as control samples as well. Results show that using 50 gr super-absorbent halved irrigation amount (5 lit) in 10-day period intervals. Using 100 gr super-absorbent with 10 lit water increased period of irrigation from 10 to 20 days. Also applying super-absorbent increased in height growth and diameter at collar growth compared with controls. We conclude that super-absorbent can diminish water consumption and irrigation frequency by 50%. We therefore find this method economically justified and suggest it for restoration ecology projects in arid and semi-arid regions such as Zagros forests of western Iran.

# The resilience of cork oak ecosystems subjected to drought and recurrent fires: is there an additive effect?

Dr Thomas CURT - Cemagref, GR EMAX Aix en Provence - France

Cork oak (Quercus suber) ecosystems form a remarkable habitat in the Mediterranean area, which is subjected to recurrent fires and droughts. Although this species is expected fire-resistant and especially resilient due to its high resprouting ability, symptoms of forest decline are around the Mediterranean basin, and notably in the Maures massif (south-eastern France). To investigate to which extent this decline could result from the addition of drought to the direct effects of fires we established 40 permanent plots just after the large and intense 2003 wildfire to survey individually the tree mortality and resprouting from until 2010. This period included a severe drought period (2003-2006). We also studied 123 plots to survey cork oak regeneration from seeds. We assessed the vegetation biomass and covering in the field and using remote sensing to calculate the normalized difference infrared index (NDII). The results indicate that the 2003-2006 drought added to the direct effect of fires, with higher delayed mortality, limitation of recruitment from seeds. However, the habitats including cork oak recovered their pre-fire and pre-drought covering due to the high resprouting ability of cork oak and the recovery of understory shrubs.

## Actualisation du catalogue des pteridophytes du nord ouest algérien en relation avec le changement climatique (cas de la region de Tlemcen)

Medjahdi BOUMEDIENE - Université de Tlemcen - Algeria
Letreuch BELAROUCI ASSIA - Université de Tlemcen – Algeria
Letreuch BELAROUCI NOUREDDINE - Université de Tlemcen - Algeria

Sans doute le réchauffement climatique et ses conséquences sur les milieux naturels sont parmi les grandes préoccupations de la communauté scientifique ces derniers temps. Ces conséquences sont particulièrement graves pour certains taxons. Les ptéridophytes sont l'un des groupes les plus sensibles aux éventuels changements climatiques. En effet, les espèces de ce groupe généralement sciaphiles, se trouveront dans les limites de leurs capacités de survie. Un inventaire des ptéridophytes a été entrepris dans les forêts de la région de Tlemcen. L'inventaire de ces populations constitue une étape importante pour le développement des stratégies de conservation des ressources génétiques et de la diversité de ces populations sur l'ensemble de leur aire de distribution naturelle. Nous avons ainsi effectué le recensement et l'identification des fougères existantes dans la région de Tlemcen. Au total, plusieurs stations dont les caractéristiques écologiques diffèrent d'un site à un autre ont été prospectées, ils ont permis l'identification de 27 espèces (dont 5 exceptionnellement rare). La création de réserves naturelles forestières renforcée par une protection réglementaire des espèces les plus menacées est nécessaire pour le maintien de ces communautés si particulières.

# CLIMATE CHANGE AND ECOSYSTEM SERVICES

# Menage influence on depositing of carbon in the oak forests (Western region of Ukraine)

Serhiy KOPIY - National forestry and wood technology university of Ukraine - Ukraine

Common oak is one of the most valuable tree species growing on the territory of Ukraine and within the study region in particular. Oak-participating stands in addition to being a valuable raw material source, fulfill most important soil protection, water-regulation, water-conservation and recreational functions. By absorbing a considerable amount of surface water, they substantially diminish the surface, run-off and subsequently, reduce water erosion. In the past the geographic range of common oak was much wider than the present one, but in response to adverse environmental effects as well as intensive human management activity, its range of distribution has significantly reduced in size. The oak forests suffered the most losses in the study area during the period of 16th-19th centuries. The intensive forest cutting contributed to a decrease in the area of highly-productive oak forests. At the same time, since the mid-20th century, a tendency for an increase in the area occupied by oak-predominant stands has became evident in Ukraine.According to the statistics data on the forest area inventory in 2002, the total oak stands area of the government agency of forest resources in Ukraine, amounts to over 1,7 mln ha, which corresponds to nearly 27 % of the forested area within the western Forest-steppe and the pre-Carpathians zone, oak-participating stands cover over 461500 ha, that is about 27,1 % of the oak stands total area in this country. The age structure of the stands analyzed, is essentially disturbed. A major portion is made up of middle-aged stands (over 57.2%), somewhat less is represented by stands of sapling stage (21.1%), and the smallest part is made up of mature stands (6.3%).Primary plantation must consist of a 30-70 % oak wood and 10-30 % hornbeam wood. Then such plantation will be most productive and ecologically proof and will fix most of carbon.

## How can reforestations be financed through carbon credits?

Moriz VOHRER - CarbonFix Standard – Germany

Reforestations could be a major driver to reduce $CO_2$ in our atmosphere. In 2011 the number of A/R projects on the voluntary market has passed the Kyoto market! The presentation gives an overview on how organisations can benefit from the sale of carbon credits to finance their reforestations in France, Europe and the rest of the world.

## Fighting water scarcity to maintain forest environmental services - perspective of lowland floodplain forests in south eastern Europe

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Dr.sc. Boris VRBEK - Croatian Forest Research Institute - Croatia
Stjepan DEKANIĆ dipl.ing. - Croatian Forest Research Institute - Croatia
Tomislav NEMEŠ dipl.ing. - Croatian Forest Research Institute - Croatia

The development of various forest environmental services in Europe are closely related to water status of forests under the future progression of climate change across the regional gradient. Current scenarios (IPPC) predict a shifting of climate variables towards more beneficiary conditions for forests in Northern Europe and increasing droughts and water scarcity in the South-East. Climate trends in Croatia, situated on the junction of Mediterranean and south-east Europe, predict an increase of summer temperatures, a decrease of precipitation during spring-autumn seasons until 2070 (UNDP 2009) and a decrease of annual river discharge. Due to the spreading across three climate zones (Mediterranean, mountainous and continental), the development of various environmental conditions contributed to the presence of various forest types with extensive biodiversity. By far the most valuable forest resources present hardwood oak forests which cover an area of more than 200,000 ha and are situated in the continental lowland part of the country. The trends of the forest condition in Europe and Croatia confirm that the most damaged European tree species are common and sessile oaks with an average crown damage status of 35%. During the past decade there was strong evidence of hydrologic changes in terms of runaway decline of groundwater tables followed by immense forest decline. The objective of this work is firstly to evaluate the regional impact of climate change (warming, dry spells) on the hydrology of lowland forests in Croatia, predominantly trends and the seasonality of groundwater tables as a most disturbed hydrologic component. For the purpose of observations of the impacts, the regional long-term groundwater monitoring system of piezometric network (FORHIS) proves unavoidable. The second objective of this work is to evaluate possibilities of drought impact reduction through silvicultural and hydro-technical measures in forests aimed on water preservation. At the landscape level, these measures comprise temporal preservation of winter precipitation to secure more favourable soil water status during the first part of the growing season because the amount of winter precipitation is not subject to changes according to the regional climate scenarios. Consequently there are various possibilities of constraints on the surface runnoff during the winter season using the lowland microtopography; construction of forest roads to create depression storages, closing drainage ditches and the re-watering of old natural dry watercourses to stop exfiltration (flow of water out of the soil).

# Development of a Web Based Explorer for Forest Ecosystem Services (WEFES)

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PhD Barbara, HOCK - SCION - New Zealand
PhD Davida, PALMER - SCION - New Zealand
PhD Tim, PAYN - SCION and Lancare Research - New Zealand

With increasing demand for resources from an increasing global population and concerns about impacts from climate change, the pressure on land resources is becoming intense with competition for land, food, fiber, and energy production and increasing demands on water supply across all of these activities. International and national initiatives that are focusing on enhanced productivity with minimal environmental impact (sustainable intensification) are gathering steam and aiming to address these concerns. Core to any land use decision making is the need for information, data, models, and knowledge. As long as the complexity of need expands, the difficulty of providing, managing and manipulating such knowledge expands with it. Web 2.0´ developments - web applications that facilitate participatory information sharing, interoperability, user-centered design, and collaboration, opens up the opportunity to use data in ways previously impossible and to develop systems and approaches that will allow users to work in different ways. In 2009 an international collaborative project ´TRANZFOR´(www.tranzfor.eu) was established to enhance intercontinental activities in the area of forests and climate change. One area of work established was that of forest ecosystem services (ES) with the aim to allow a more holistic view of forests and their products and services and their contribution to wider society. Forest based ES typically fall in the provisioning of erosion control, biodiversity maintenance, clean water, flood mitigation, greenhouse gas mitigation, recreation. These are values that are additional to any traditional timber values and are generally poorly identified with respect to a forest and have only a nominal recognized value. Improving recognition and value are an important international priority as these values can then be used in improved land use decision making based on triple bottom line rather than pure economics - the downfall of previous civilizations. The focus of this work focuses on Web 2.0 concepts to design a system that deals with forest ecosystem services. The team assembled incorporates spatial and temporal forestry, environment and modeling skills, web based design, data management, manipulation, visualization, and delivery capability. The goal of the project is to develop a web based concept that makes the most of web technologies to enhance decision making related to development of forests for multiple benefits.

# PICUS v1.6 – enhancing the water cycle within a hybrid ecosystem model to assess the provision of drinking water in a changing climate

Andreas SCHIMMEL - University of Natural Resources and Life Sciences, Vienna, Institute of Silviculture - Austria
Werner RAMMER - Austria
Manfred J. LEXER - Austria

The PICUS model is a hybrid ecosystem model which is based on a 3D patch model and a physiological stand level production model. The model includes, among others, a submodel of bark beetle disturbances in Norway spruce and a management module allowing any silvicultural treatment to be mimicked realistically. It has been tested intensively for its ability to realistically reproduce tree growth and stand dynamics in complex structured mixed and mono-species temperate forest ecosystems. In several applications the models capacity to generate relevant forest related attributes which were subsequently fed into indicator systems to assess sustainable forest management under current and future climatic conditions has been proven. However, the relatively coarse monthly temporal resolution of the driving climate data as well as the process resolution of the major water relations within the simulated ecosystem hampered the inclusion of more detailed physiologically based assessments of drought conditions and water provisioning ecosystem services. In this contribution we present the improved model version PICUS v1.6 focusing on the newly implemented logic for the water cycle calculations. Transpiration, evaporation from leave surfaces and the forest floor, snow cover and snow melt as well as soil water dynamics in several soil horizons are covered. In enhancing the model overarching goal was to retain the large-scale applicability by keeping the input requirements to a minimum while improving the physiological foundation of water related ecosystem processes. The new model version is tested against empirical time series data. Future model applications are outlined.

## Ecological services of temperate forests at the forest/steppe limit

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Topic: to be decided by the Advisory Committee In Southeast Europe distribution of forests is determined and limited primarily by climatic aridity. In this vulnerable region the expected reduction of the forested area due to the recurrent severe droughts as well as planned afforestations have a significant feedback to the atmosphere. Our study represents the first assessment of the climatic role of forests in this region and their role in the mitigation of the projected climate change. 1D-hydrologic model simulations calibrated on field measurements, the MM5 mesoscale meteorological model and the regional climate model REMO have been applied to analyse and quantify the biogeophysical feedbacks i.e. ecological services and climatic effects of forests in Hungary. Biogeochemical processes (e.g. CO2 sequestration) have not been considered. The presentation focuses on the following questions: ♣ What have been the biogeophysical effects of land cover change in the 20th century? ♣ What would be the effect of shift in the ratio of forests and grasslands on evapotranspiration and groundwater consumption? ♣ Could an increase of future forest cover alter the projected climate change signal? Land cover change in the 20th century resulted in considerable increase of forests (from 12,5 to 21,1%) and urbanized areas (from 2,4 to 5,7%) resulted in a +0.15°C warming of daily mean temperature nation-wide, while the rate of local warming (especially in the environs of cities) exceeded +1°C. In spite of the fact that land cover changes did not have a significant impact on total precipitation nation-wide, the effect on precipitation distribution and intensity was considerable (in some cases there were local changes greater than 40mm). Based on a local case study, the larger leaf area and deeper roots of forests led up to 30% larger amount of evapotranspiration and almost three times higher groundwater consumption than for the grasslands. Based on these results, for the future the proposed afforestations have only a slight effect on climate on country scale. But assuming larger contiguous forest blocks, the increase of forest cover can mitigate the strong tendency of warming and drying projected for the end of the 21st century. These assessments of the role of forests in the climatic processes and interactions can provide useful information for the adaptation and mitigation strategies in forestry and water management.

# Multipurpose management of forests: carbon. biodiversity and socio-economic well-being: Objectives, Actions and Expected results of LIFE+ project "ManFor C.BD"

Dr Bruno DE CINTI - IBAF-CNR - Italy
Dr Giorgio MATTEUCCI - ISAFOM-CNR - Italy
Dr Primoz SIMONCIC - SFI - Slovenia
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Dr Gianfranco FABBIO - CRA-SEL - Italy

Is it possible to test the effectiveness of multifunctional forest management? Is is possible to provide data on Pan-European indicators for Sustainable Forest Management (SFM)? Is it possible to inform communities about forest management objectives, results and perspectives? The answers to these questions are at the base of the LIFE+ project ManFor C.BD "Managing Forests for Multiple Purposes: carbon, biodiversity and socio-economic wellbeing" (LIFE09/ENV/IT/000078 - 01/10/2010 -30/09/2015), co-financed by the European Union with € 2'483'271 (5'020'902 € Total cost) and coordinated by the National Research Council of Italy (CNR, with two institutes). Other partners are: Molise University; Agriculture Research Council (CRA, three Research Centers), Veneto and Molise Regions, Slovenian Forestry Institute. The project aims at verifying in the field the effectiveness of multipurpose forest management, providing data, guidance and best-practice. Data on indicators for SFM will be collected, with particular emphasis on those related to carbon and biodiversity. Additional indicators will be developed and tested. The project will address these issues in production and protected forests, including Natura 2000 sites, along a N–S transect (Italy) and an E-W transect (Slovenia to Italy) (10 sites). In the selected forests, regularly managed, the project will evaluate traditional management practices and will design, implement and evaluate new management practices. The demonstration-extension character of the project will be focused on providing information on forest management, forest inventories and landscape patterns from local to national communities and in setting-up forest management demonstration areas. We expect to achieve: i) knowledge about the effectiveness of forest management practices in meeting multiple objectives; ii) Data and policy relevant information about the impact of forest management on carbon cycling and biodiversity; iii) datasets about SFM MCPFE and additional indicators; iv) Evaluation of management effects at different scales, taking into account ecological connectivity; v) definition of a set of “good practices”; vi) Assessment of the impact of forest management options on selected vertebrate and invertebrate taxa; vii) Increased awareness on multifunctional forest management at the public and societal level; viii) Establishment of test areas to follow long-term trends of forest biodiversity and carbon cycling in response to forest management.

# Evaluating the carbon sequestered by forest systems.

# Comparison of two methodologies.

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Carbon sequestration has become an important topic in forest management nowadays, especially in the light of concerns about global warming. The two methods commonly described in the literature to account for the carbon captured in forest systems are based either on the estimation of the carbon employing the growth of the trees provided by the inventory or on the comparison of the existences provided by two consecutive inventories. Due to the importance that the correct accounting of this carbon at the national level implies, both methods have been compared at the regional level employing data from the II and III Spanish National Forest Inventory. The study case chosen is the region of Andalucia, which is located in the Southern part of Spain and it is characterized by its Mediterranean climate. Andalucia comprises more than 8 million hectares where 3.882.762 ha are occupied by forest land. Data from 11.603 permanent plots distributed throughout the region have been analyzed employing the two methods formerly described. Regarding the emissions, they have also been evaluated spatially throughout the territory. Preliminary results show some differences between the carbon sequestered computed by the two methodologies, as well as changes in the direction of the capture/emission in some areas of the territory depending on the method considered.

## Water and carbon use of a cork oak forest north Tunisia: quantification and possible effects of climate change?

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In South Mediterranean basin, water and carbon are one of the important environmental services of the cork oak forest. They also considered the key element of its decline. The objective of this investigation is to quantify the seasonal and annual water and carbon use of a cork oak forest in north Tunisia. The experimental design was carried out during the 2008 and 2009 vegetative seasons. It consists to the follow-up of trees sap flow densities and monthly measurements of photosynthesis rates. Usual climatic parameters, soil moisture, radiation, temperature, wind and humidity are measured using an automatic weather station. Trees transpiration (Tr) indicates a similar evolution to climatic demand (ETo Penman) with a weak deceleration during July-August. Trees transpiration accounts for 40% of ETo and 30% of annual rainfall and has reached a maximum value of 2.8 mm/j. Drainage and Runoff estimates using simplified water balance are almost 24% of annual rainfall. Average photosynthesis marks a clear growth since March to June period and reached a maximum value of Pn = 13 μmol.m -2 s -1 and it drops appreciably during August and July (Pn = 4 μmol.m -2 s -1). For an average leaf area index of Lai=1 to 2.5, leaf carbon assimilation can be estimated between 4 and 6 TC/ha/year. Most climate change models predict for north Tunisia an increase of temperature and bigger variation of rainfall. Possible consequences of such modifications on water and carbon use are discussed.

# RISKS AND UNCERTAINTIES

# Implementation of risk and crisis management concepts to mitigate windstorm impacts in Belgium

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Past storm events and present uncertainties over climate change effects on forest ecosystems recently forced the regional forest services of Wallonia (Belgium) to integrate the concepts of risk and crisis management into their policies in order to mitigate economic, social and environmental impacts of these kind of hazard. This paper aims to introduce the theoretical concepts and practical tools developed to help decision-makers and managers to react as quickly as efficiently after a huge windstorm event. We mainly focused on three aspects of such crisis : the development of a fast damage assessment methodology, the alleviation of economic impacts through the use of a decision-making tool and the implementation of emergency planning concepts into the administrative management. Windthrow damage assessment is a key factor for a successful crisis management because a fast and accurate estimation of the amount of wood blown down by the wind is needed by the decision-makers to determine the severity of the situation and then adapt the level of response. Thus, a simple and fast methodology for damage assessment have been developed in order to get an estimation at a regional scale within a 72 hours delay. This field evaluation is based on the 5,500 plots of the permanent inventory of regional forest resources. This one enables a calculation of damage simply by counting the uprooted or broken trees in the experimental plot. Furthermore, decision-makers and managers were frequently lacking a whole vision of the wood mobilization chain while they have to establish the best strategy to harvest, store and transport the damaged timber. As we know that public financial incentives are not going to increase, it will be absolutely fundamental to optimize these forest operations. Therefore, we developed a decision-making tool by modelling this mobilization chain which enables to compare crisis scenarios and to choose between crisis measures. Nevertheless, we also wanted to change the perception of crisis management by forest managers and to strengthen the solidarity between the forest-based sector stakeholders to deal with forthcoming disasters. That’s why the emergency plan is by now the official framework for risk assessment, preventive actions and crisis management and has to be implemented as quickly as possible in the daily management of Walloon forests.

## Analysis of forest ecosystem vulnerability with satellite data in semi arid region in the north west of Algeria

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Engenier, Djamel, MANSOR - Centre of spaces techniques - Algeria

The Forest in Algerian steppe present ecological diversity, and seen climatic unfavourable conditions in semiarid zone and forest fires impact; we notes deterioration of physical environment particularly, deterioration of natural forest. This deterioration of forests provokes an unbalance of environment witch provokes a process of deterioration advanced in the ultimate stadium is degradation and desertification. By elsewhere, where climatic conditions are favourable, the fire is an ecological and acted agent like integral part of evolution of the ecosystems, the specific regeneration of plants are influenced greatly by the regime of fire (season of fire, intensity, interval), which leads to the recuperation of the vegetation of meadow- fire. In this survey we used the data of Algerian satellite ALSAT for detection of zones with risk of forest fire and their impact in natural's forests ecosystem in North West of Algeria. A thematic detailed analysis of forests well attended, different processing of satellite data allowed us to identify and classifying the forests in their opinion components flowers. We identified ampleness of fire on this zone also. Some parameters as the slope, exposition, species and naturals populations of forests formations were studied in the goal of determining the zones to risk of forest fire. A crossing of diaper of information in a GIS according to a very determined logic allowed classifying the zones in degree of risk of fire in semi arid zone witch forest zone not encouraging the regeneration but permitting the installation of cash of steppe which encourages the desertification.

# Incorporating forest wind risk in climate change adaptation strategies

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A changing climate presents challenges for forest managers in deciding how forested areas may be best adapted to make them resilient, and to preserve, or improve, their economic, social and environmental benefits. Forest adaptation plans commonly include changes to tree species and modifications of management regimes. Informed decisions on appropriate forest adaptation strategies will require both the quantification of the impacts of each strategy, and projections of how key biotic or abiotic risks would be expected to change. Adaptation strategies were developed for an upland forest case study in north Wales, and the wind risk implications were explored using the ForestGALES model. Potential changes in wind risk from increased or decreased rainfall and frequency of storms were examined in a climate change sensitivity analysis based on changes to forest stand water-table depth, and wind speed distribution parameters (Weibull a and k), using the research version of ForestGALES.

# Approaches to assess forest and water interactions in the NW-European ForeStClim headwater catchments in response to a changing climate

Dr. Steffen SCHOBEL and Prof. Dr. Gebhard SCHÜLER - Research Institute for Forest Ecology and Forestry Rheinland-Pfalz - Germany

In a changing climate convective storm rainfall events in summer and wet winters are expected to threaten an increasing number of smaller catchments by (flash) floods. Adaption strategies for a preventative flood risk management are necessary to reduce the potential scale of damage. In order to meet such an objective, hydrological model applications are commonly used to run various scenarios as a decision support. But the range from a fragmentary scientific understanding of the specific run-off processes in differently featured catchments to a lack of required data and the broad field of model uncertainties still limit the validity of the applied model. Hence, within the NW-European INTERREG project ForeStClim (www.forestclim.eu) the forest, soil and water interactions are investigated extensively by self-measuring and surveying the parameters needed to fit the SWAT/APEX model as much as possible to reality. In addition, the specific dominant run-off processes of the presented catchment were identified by sprinkling experiments and summarised to an expert system which enables the mapping of run-off generation units. This approach offers the possibilities to locate the areas of quick flow generation and to implement appropriate countermeasures on-site (afforestation for an example). On the other hand, the model approach gains no hydrological insights, but a well validated model enables the assessment of such countermeasures and further scenario studies according to specific changes in climate or/and land use distribution. As a result we confirmed the soil conditions as an important regulator of water retention. Agriculture can reduce the infiltration near soil-surface (sealing, compaction) so that the potential water retention of the subsoil is disabled. A change in land use can reactivate this retention potential, but nevertheless it is limited of course. For instance, in case of snow melting combined with massive precipitation and saturated soils, the percentage of forested areas in a catchment has no impact on flood generation. Consequently, the benefit of forests in mitigating run-off and reducing flood peaks is most pronounced for small, frequent flood events.

# The analysis of forest fire weather indices in the Slovak Paradise National Park in relation to the risk of climate change

Prof. Dr. Jan HOLECY - Technical University of Zvolen - Slovakia
Prof. Dr. Jaroslav SKVARENINA - Technical University of Zvolen - Slovakia

The contribution informs about results provided by the statistical analysis concerning the recorded values of selected fire weather indices (Angstrőm index, Baumgartner index and Nesterov index) and corresponding population proportions of forest areas destroyed by fire in the given experimental territory during particular years of the 1971 – 2010 period. The development trends of observed both the climatological and fire occurrence risk data have been investigated by the method of moving averages that enables to reduce the dispersion of data recorded during particular years. As the measures of a climate dynamics in the whole experimental territory the annual accumulated values of all 3 evaluated indices were selected. In order to detect assumed differences in climate observed during particular investigated decennia the values of arithmetic means of all these 3 indices have been mutually compared by using their empirical distribution functions describing their specific seasonal development. These empirical distribution functions have been modelled by using a Weibull two parameter probability distribution. So the random deviations of the observed data from their trends have been reduced again. At testing the significance of detected differences between the couples of particular accumulated values of all indices the Kolmogorov – Smirnov two sample test has been applied. As the most sensitive measure able to reveal the assumed change of climate within the given area has proved to be the Angstrőm index. The danger of forest fire ignition and propagation can be estimated by using different fire weather indices that depend on the occurrence of extreme climate and weather quantities. The obtained results point out the significant increasing trends of both the fire weather indices and corresponding forest fire occurrence rates describing the forest management risk themselves.

# MANAGEMENT FOR ADAPTATION

# Adapting forest in Central Europe to climate change – the role and perspective of adaptive management

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Climatic warming may lead to increased or decreased future forest productivity. However, more frequent heat waves, droughts and storms and accompanying pathogen attacks are also expected for Europe and are considered to be increasingly important abiotic and biotic stress factors for forests. Europe's forestry sector is vulnerable to climate change due to the long rotation period of most of the forests. Adaptive forestry can help forest ecosystems to adapt to future conditions in order to achieve management goals, maintain desired forest ecosystem services and reduce the risks of forest degradation. With a focus on Europe's temperate and boreal zones, this paper presents the following management strategies: (1) conservation of forest structures, (2) active adaptation, and (3) passive adaptation. The feasibility and criteria for application of the different strategies are discussed. Forest adaptation may entail the establishment of 'neonative' forests, including the use and intermixing of native and non-native tree species as well as non-local tree provenances that may adapt better to future climate conditions. An integrative adaptive management concept is proposed that combines (1) species suitability tests and modelling activities at the international scale, (2) priority mapping of adaptation strategies at the national to regional scale, and (3) implementation at the local scale. To achieve this, an international experimental trial system is required to test suitable adaptive measures throughout Europe and worldwide.

# Sensitivity of forest ecosystem goods and services to spatial configuration of forest properties

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The future spatial and temporal distribution of forest ecosystem goods and services (EGS) are expected to depend on two main factors: 1) how climate change will impact forest states and 2) how, where and when forest management is implemented to mitigate negative climate change effects. Forest landscape models (FLM) that account for forest heterogeneity and the interaction between the above mentioned factors are commonly used to evaluate adaptive management plans. However, empirical forest data, which are fully spatial and at a fine enough resolution, are rarely available to initialize these models. Thus, FLM are commonly initialized using a combination of sparse empirical data and model-derived initialization data (e.g. the simulated forest at an equilibrium state under current management). Here we first assessed how forest dynamics and the spatial distribution of EGS are affected by the data FLM are initialized with. Second, we test how sensitive adaptive forest management plans are to the initialization data, focusing on the degree to which initialization data influence whether or not EGS should be spatially segregated or jointly managed. We used the FLM LandClim to evaluate three types of initialization data: interpolation of forest structure using fine and coarse grain empirical data, and simulated forest structure. We tested these initialization data sets across a range of forest management and climate change scenarios in a case study in the Black Forest, Germany. In this region timber and biodiversity are the most important forest EGS. Our results demonstrate that simulated forest dynamics are sensitive to the type of initialization data that is used. These differences arose due to interactions between the initialization data and the simulation of tree regeneration, growth and mortality that are primarily important when forest dynamics are evaluated at a fine grain. When evaluated at the landscape scale, the type of initialization data used had a small impact on how climate change is predicted to influence forest EGS. However, when evaluated at an intermediate scale, the degree of spatial autocorrelation in the initialization data did influence where and when adaptive management actions were implemented. Therefore, the degree to which connectivity is considered in the assessment of EGS provision determines the importance of the spatial forest management allocation scheme and hence the distribution of EGS. We discuss the benefits and caveats of the evaluated initialization approaches and highlight the need for considering trade-offs between local and landscape-scale EGS provisioning when developing adaptive forest management strategies.

# Challenges and Opportunities for the Assisted Migration in Managed Forest

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Although initially conceived for endangered species, the idea of Assisted Migration (AM), i.e. the intentional translocation of populations to compensate for climate change related risks, is receiving increasing attention for adapting managed forests to climate change. However, there is very little consensus regarding the conditions (ecological and legal) necessary to implement such initiatives. In particular, concerns about genetic pollution of target populations, local adaptation of source populations and translocation of incompletely adapted seed sources imply close scrutiny of potential AM projects. Moreover, the commercialization of forest resources are bound by international agreements (EU directives and OECD protocols) which puts certified seeds at the center of AM initiatives. Here, we identify current limitations in ecological research, forest resource management and legislation that need to be overcome before implementing AM programs in a sustainable way in France and the EU. Finally, we briefly introduce the project "AMTools" (ANR AgroBiosphere) starting in 2012 that will analyze two hypothetical programs of assisted migration in the northern continental plains of France and the French Alps by means of ecological simulation of tree survival using provenance test data, formal decision theory and public policy analysis.

# Does thinning contribute to regulate nutrient cycling in Mediterranean oak-pine forests?

Dr. Andres BRAVO-OVIEDO - CIFOR-INIA - Spain
Dr. Miren DEL RIO - CIFOR-INIA - Spain

Mediterranean mixed forests services are threaten by global change. Good and scientific based management practices are needed in order to sustain ecosystem services. We present the effect of thinning on Mediterranean oak-pine forests nutrient cycling and tree growth. A latin-square statistical design of two thinnings intensities and a no-intervention prescription is analyse. Soil litter accumulation one year after thinning, litterfall during one year after thinning and leaf-needle decomposition during one year is compared. Results are discussed and compare with pure stands. Moderate thinning regime improved growth and preserved nutrient cycling during periods of low litterfall production. However, under dry periods litterfall rates increased significantly in control plots.

## Testing Establishment Success of Mediterranean Beech in Swiss Forests

Prof. Urs MUEHLETHAELR - Bern University of Applied Sciences - Switzerland
PD Dr. phil. nat. Andreas STAMPFLI - Bern University of Applied Sciences - Switzerland
Regina KURSCHAT - Bern University of Applied Sciences - Switzerland

Climate change is swiftly gathering pace and is significantly affecting Swiss forests. The question of whether Mediterranean beech is able to establish in Switzerland, under current climatic conditions, and whether it is more drought-resistant than local beech, is being investigated. Seeds of 14 provenances from Italy, Slovenia and Switzerland were sown on five experimental sites in forests near the drought limit. Germination, establishment success and growth parameters are being monitored for single mother trees of these provenances. In addition, the response of Swiss and Mediterranean provenances to an experimentally-simulated summer drought is being tested on seedlings under more controlled conditions in a tree nursery. The results of these experiments may contribute to the issue of the general adaptability of beech forests regarding climate change. Will assisted migration help to enhance the fitness of beech ecosystems in the long run? What are the possible risks and opportunities?

# What is the potential of the oak in the Upper Rhine Valley?

Dr. Charalambos NEOPHYTOU - Forest Research Institute of Baden-Württemberg - Germany
Dr. Hans-Gerhard MICHIELS - Forest Research Institute of Baden-Württemberg - Germany

Since their post-glacial migration oaks have been an important element of the natural vegetation in the Upper Rhine Valley. From the ecological point of view, they form forest ecosystems with a rich structure and a very high biodiversity. In terms of forest management, they are not only an important source of construction and fuel wood, but they provide a series of non-wood forest products. Having wide ecological amplitude, oaks are expected to be a key species for future forestry. However, due to changes in forest management, oak regeneration has been problematic since several decades and requires big effort from forest managers. The Interreg-IV project "The regeneration of oak in the Upper Rhine lowland" deals with this problem on both sides of the Upper Rhine Valley, in Alsace (France) and Baden (Germany). It aims at conservation of the oak as an element with a major economical, ecological and cultural importance. Through a network of 66 reference stands, the genetic resources of oak species, along with site conditions and growth data, are inventoried in the research area. By means of various molecular markers, arising from neutral and adaptive regions of the DNA, insights into genetic variation and its spatial distribution are gained. A high genetic diversity is a prerequisite for a high adaptive capacity. With its results, the project aims at serving forest practice, both from the conservation and from silvicultural point of view.

# Climaq - Adaptation des forêts d'Aquitaine aux changements climatique : Un programme pour préparer l'avenir

Cecile MARIS - CRPF - France

L'objectif de Climaq est l'intégration du risque "changement climatique"à la gestion courante des forêts d'Aquitaine. Le programme réunit 5 partenaires forestiers aquitains (CRPF, CAFSA, FCBA, INRA, ETF d'Aquitaine) autour de 3 axes de travail : Axe n°1 : recherche d'essences et de provenances susceptibles d'être mieux adaptées aux évolutions climatiques pressenties Axe 2 : Développement, bilan économique et évaluation environnementale des peuplements à vocation énergétique permettant : La réduction de la durée des révolutions, la diversification des itinéraires techniques, la production d'une source d'énergie renouvelable permettant d'atténuer les effets du changement climatique Axe 3 : Transfert des connaissances sur le changement climatique et l'adaptation des forêts auprès des sylviculteurs et des gestionnaires.

# Do afforestation subsidies in the Czech Republic contribute to climate change adaptation?

Mr. Vojtech KOTECKY - Charles University Environment Center - Czech Republic

Public subsidies are a major economic factor in the European forestry sector. Besides that, they may play an important role in climate change adaptation. The Czech afforestation subsidy is, by far, the largest forestry-linked incentive scheme in the country. The government spends more than € 9 million a year on the programme, funded from both the EU and national budget. The research explores whether the subsidies contribute to climate change adaptation in two respects: do they (i) support a tree species mix which is relatively more resilient to a warmer climate, and (ii) stimulate restoration of floodplain forests that will improve flood protection?

# Afforestation programs to reduce climate change impacts on forest lands in kardzhali region (Bulgaria)

PhD Student Borislav YANGYOZOV - Forest Research Institute – Bulgaria

The existing climate change models span a broad range, making it difficult to predict the future climate, particularly at the regional level. The potential effects of climate change on forests differ significantly as different forest structure and composition have their potential responses to climate change. Forest plantations, are potentially an object of significant human intervention as a measure to mitigation the negative effect of climate change. Almost 17 000 ha or 47 % of the total forest area were afforested in the region of Kardzhali from 1946 to 2010. Various forest tree species (Pinus nigra, Pinus sylvestris, Cedrus atlantica, Quercus rubra, Robinia pseudoacacia, etc.,) were used for implementation of different afforestation programs. In the first 10-20 years of afforestation activities in this oak region, mainly forest plantations of coniferous tree species were established – more than 80%. As a result of the researches on climate change, there is a sustainable tendency of increasing the percentage of deciduous tree species and decreasing this of the coniferous - in the last decades, the percentage of the deciduous tree species plantations increased to more than 40%. Object of study is the status of the plantations - their survival and growth indicators, in condition of dynamic climatic characteristics. The trends of change of precipitation and air temperature were analyzed to determine the influence of climatic conditions on the plantations, as well as the response of the different tree species. The results of the analysis give directions to future management of forest plantations as a measure to mitigate the negative impacts of climate change.

# Forest water budget as affected by stand composition and tree density

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In temperate areas, the climate change is gradually leading to an increase of winter rainfalls, but also to a decrease in summer rainfalls combined with a rise of temperatures. In parallel to these mean trends, an increase in extreme events (floods, droughts, heat waves) is observed and submits ecosystems to high stresses. Forests are particularly vulnerable to these pressures mainly because the longevity of trees does not allow them to genetically adapt quickly. Therefore forest managers may improve forest water balance, either by introducing species that consume less water, or by reducing the number of trees uptaking water. We studied these options in pure and mixed forests of sessile oak – Scots pine (Quercus petraea, Pinus sylvestris) in the French plain. These stands are frequently found on poor hydromorphic sandy soils with a temporary perched water table but with low soil water storage capacity; consequently they are frequently subjected to flooding in winter and to summer water deficit. The volumetric water content (VWC) of soils was measured at different depths (from 10 to 80 cm) by the TDR methodology, whereas the incident microclimate was recorded in parallel (rainfall, soil and air temperatures, radiation), in addition to stand characteristics (stand basal area, tree density, understorey species identity and cover). Over one year of survey, relative volumetric water contents (VWC/VWCmaximum) were higher in soils under the pure pine stand, followed by the mixed stand, and the lowest under the pure oak stand whatever the considered soil depth and stand characteristics. Theses results suggest that mixed oak-Scots pine stands have a lower water consumption and as a consequence water deficit stress could be reduced compared to pure oak stands. However, we also found that the mixture does not seem to help to reduce the period of water flooding, which is a limiting factor to oak growth in spring. Besides, we found a relationship between stand basal area (ranging from 25 to 34 $m^2$/ha) and rate of relative VWC decrease, suggesting that fewer trees per hectares reduce water consumption of the system, as assumed. Nevertheless, forest managers could reduce the stand basal area below 20 $m^2$/ha, which often leads to overdevelopment of understorey plant species which, in turn, can have a high water consumption. We are carrying out experiments to monitor soil water content and determine the role of different understorey species (mainly Calluna vulgaris, Pteridium aquilinum, and Molinia caerulea) in the global water budget of mixed and pure stands with different structures and different tree densities.

# Forests and Climate Change - a Swiss Research Program

Dr. Peter BRANG - WSL Swiss Federal Institute of Forest, Snow and Landscape Research - Switzerland
Dr. Sabine AUGUSTIN - FOEN Federal Office of the Environment – Switzerland
Dr. Julia BORN - of Forest, Snow and Landscape Research - Switzerland

The changing climate has in the long term the potential to put forest ecosystem services and products at risk. However, the complexity of the interactions between climate, forests, forest management, and forest services and products as well as the uncertainty involved make it difficult for managers to take appropriate action. The research program 'Forests and Climate Change' aims at providing the knowledge needed to increase the adaptive capacity of Swiss forests in a changing climate. Started in 2009, it now encompasses 25 research projects addressing many relevant issues, from the climate itself over impacts on forests to adaptation. The poster presents the program structure, and selected preliminary results.

## PlantaComp: a forestry experimentation network for studying adaptation to climate change

ANGER Christel - INRA - France
SERGENT Anne-Sophie - INRA - France

During recent years, researches on climate evolution have progressed considerably and the results of the latest IPCC report confirm a climate change of which we already feel the effects and which will increase during the 21st century. It will result in a rise in temperature, a modification of rainfall regimes and probably an increase in extreme climatic events. The forest will be able to contribute to the mitigation of this climate change. However, it will also have to suffer the consequences in terms of biodiversity, growth, health risks and regeneration. To face this change, possibilities of adaptation of different tree species must also be studied. To address this issue, it is necessary not only to have information on tree species needs but also on their capacities of adaptation and on their plasticity in various environments. To be representative, this information must have been obtained from samples coming from the entire species natural repartition area. Moreover, it is necessary to take into consideration the whole series of long term observations because of the experimentation life span. The INRA has numerous comparative trials of forestry species which have been set up for several years throughout France by genetic breeders of the Ecology of Forest, Prairies and Aquatic systems department, and which have been grouped together since 2009, in a network called PlantaComp. These experimentations, which concern several species, make it possible to compare several genetic units (geographic provenances, progenies, clones) in various environments. This group makes it possible not only to represent natural interspecific and intraspecific variability, but also to have a unique spatiotemporal dimension. The initial objectives of these tests were to study of natural diversity of forestry species and to create improved varieties for reforestation. However, for some years now, scientists noticed that this network can supply precious information on interactions between genotype and environment. It is also a useful tool for studying the adaptation of forestry species to climate change. Recently, a study has been developed from the PlantaComp network on the effect of climate change on Douglas-fir in France (a part of the Dryade ANR project).

# Adaptations of mountain forest management to climate change: can we maintain mixed uneven-aged and productive forests?

Valentine LAFOND - Cemagref de Grenoble - France
Thomas CORDONNIER - Cemagref de Grenoble – France
Benoît COURBAUD - Cemagref de Grenoble - France

Climate change is expected to increase exposure and vulnerability of forests ecosystems to natural disturbance or stresses, such as storms or droughts. Forest managers are investigating strategies to limit forest sensitivity to these risks. Some suggest increasing harvests and reducing diameter limit and/or stocking (i.e. basal area), so as to limit water competition and the amount of stock exposed to perturbations. However these practices could modify forests structures and compositions, whereas maintaining a continuous cover trough mixed uneven-aged stands is a primary issue in mountain forests, which have an essential protection function of human habitats against natural hazards (avalanches, landslides, rock falls…). Continuous cover forestry, which aims at increasing forests resilience trough settled regeneration and complementary species, could be a sustainable response to climate change. We decided to question whether these strategies (a more dynamic silviculture and continuous cover forestry) are compatible and sustainable. Our objective was to determine which management scenarios lead to satisfactory wood production while maintaining mixed and uneven-aged stands. We hypothesised that intermediate ranges of management would enable sustainable trade-offs between wood production, tree species diversity and tree size diversity. We propose a long-term simulation study based on Samsara2, a mountain forest simulation model developed for spruce-fir irregular forests of the French northern Alps, to analyse how production, diversity and structure respond to silviculture. We developed a silviculture algorithm to simulate management scenarios. We control harvesting parameters like harvesting and thinning diameters, minimal and maximal amount of harvest and its distribution among diameter classes. Stand responses to management are studied trough the Gini index applied to tree diameters, a species mixing rate, yield and harvested volume. A sensitivity analysis allowed us to determine the relative influence of algorithm parameters on the response variables as well as the domain where management objectives of wood production and adaptation to climate change reveal compatible. We present several examples of such scenarios that lead to a dynamic balance within a satisfactory range of irregular structure, species diversity, yield and wood production Although the current version of the model only takes two species into consideration, it covers a large range of the French northern Alps forests. Simulation models help understand stands response to alternative management scenarios and have thus a key role to play in the process of forest management adaptation to tackle climate change.

# CON ECO FOR (Monitoring Forest Ecosystem): an integrated approach to save the forests by the negative effects of climate change.

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Salvatore APUZZO - Regione Campania –Settore foreste - Italy
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Aniello APUZZO - Agrostudi- Castellammare di Stabia (NA) - Italy

In the recent decades climate change and O3 pollution are the main factor that influencing negatively the substrate, the growth of the trees, and biodiversity of the forests increasing the susceptibility of plants to stresses and dangers of fire. In Italy, since 1996 the CON.ECO.FOR. program (Monitoring of forest ecosystems), co-financed by the European Union and managed by the State Forestry Corps, monitors the conditions of the forests in an integrated way, making sure the changes that can occur in various biological and ecological receptors (hair conditions: transparency and non-biotic and abiotic growth and forest structure, biodiversity, chemical status of soil and leaves) in relation to environmental pressures (atmospheric deposition, gaseous pollutants, climate change). The first results of the program showed, among other things, that the ozone concentrations are high everywhere, and tend to increase over time. The increased ozone pollution was monitored in the Center-South Italy, but the biggest impact in terms of visible symptoms on plants, has been identified in the Alps area, during the summer 2003. Campania Region, with a total forest area of about 400,000 hectares of which approximately 5,400 state-owned, has always been sensitive to the problem of climate change, has put together several tools to combat this phenomenon, including the financing, through the various tools available European Union (Regulation 2080/92 and 1698/2005 which led to the Campania of the Rural Development Programme 2007-2013), programs with which it has promoted afforestation or reforestation of large areas of farmland and not. Forest reproductive material used in these programs are exclusively those from native forests by seed identified throughout the region and included in the Regional Book Basic Materials (RBBM). Through the regional project "Identification of Basic Materials in Campania" in accordance with Directive 1999/105/EC and the Legislative Decree 386/2003, the project has identified and incorporated into The RBBM different "forest seed" materials where you can pick up the propagation of different species. The use of propagation material from local forests to deliver better results in terms of engraftment and resistance to parasitic diseases, prevents pollution of the gene pool to ensure the conservation of forest bells local ecotypes and the subsequent maintenance of genetic biodiversity and thus serves to counter the effects of climate change on forest ecosystems. In this contest were reported the decadal results of this activity with enphasis to most important results obtained.

# Natural regeneration and Climate Change adaptation in Pinus nigra Arn. stands from reforestation projects

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Dr Paola BRUNDU - Ente Parco Nazionale dell'Arcipelago di La Maddalena - Italy
Dr Chiara LISA - DEISTAF, Università di Firenze - Italy
Prof.ssa Susanna NOCENTINI - DEISTAF, Università di Firenze - Italy
Dr Nicola PULETTI - DEISTAF, Università di Firenze - Italy

In many European countries in the Mediterranean area large reforestation projects have been carried out during the twentieth century with the aim of re-establishing a forest cover on degraded lands to restore soil protection function and watershed rehabilitation. Conifers have been used most frequently because of their ability to establish and grow relatively quickly on degraded soils. Resulting stands are generally quite simplified, with one species often planted over large areas. Generally the long term goal of these reforestation projects was to restore the diversity, structure, and functioning of a native forest ecosystem and management guidelines for these stands often encourage substitution with forest species which would be naturally present on the site. Expected climate change, which could significantly modify environmental conditions in many areas, introduces the question of how to manage these stands to increase their adaptive capacity. In particular, natural evolution which is already setting in could not lead to better adaptation to future climate conditions. On the other hand, artificial species substitution relies heavily on predictive capacity of climate change models. This work examines changes in species composition of the natural regeneration which is setting in under Pinus nigra Arn. stands from a reforestation project carried out between 1909 and 1970 on an area of approx. 630 ha on Monte Morello, north of Florence (Italy). These stands are already showing signs of suffering after two severe drought periods, in 2003 and in 2007. The analysis of natural regeneration has been carried out using qualitative and quantitative data collected in 2000 and in 2010. In addition, future spatial distribution of examined forest species has been modelled in a GIS in relation to IPCC scenarios. The aim is to verify if and to which degree this spontaneous transformation will produce stands that are more adapted to expected future environmental conditions and which forest management options might be more viable for increasing their adaptive capacity.

## The influence of mixed tree species stands compared with single tree species stands on within- and between-stand forest biodiversity

Dr. Nadia BARSOUM - Forest Research - United Kingdom

A common aim of current forestry policy in England, Scotland and Wales is to promote a 'diversification' of forest stands, and particularly in production forestry. This is achievable by encouraging a mixed age structure and/or favouring a mixture of different species in order to increase the structural heterogeneity of a forest stand. A number of benefits are increasingly associated with more structurally complex stands. Among these is the widely held assumption that because 'diversified' stands are more structurally complex, they offer a wider diversity of microhabitats and niches that, in turn, lead to overall increased levels of within stand biodiversity. In this study we investigate how levels of forest biodiversity respond in mixed tree species stands compared with single tree species stands. Mixed tree species stands comprised plantations of oak (Quercus spp.) intimately mixed with Scots pine (Pinus sylvestris), while single species stands were plantation monocultures of oak or Scots pine. A range of biodiversity indicator species groups were sampled. These included: vascular plants, bryophytes, carabid beetles, spiders, hoverflies, and ectomycorrhizal fungi. Several spatial scales of inquiry were used to examine the effects of not only within-stand, but also between-stand heterogeneity on the biodiversity indicator species groups. Ground-dwelling carabid beetles, for example, were studied at three spatial scales: (1) a microhabitat scale, achieved by setting up traps in open areas or under trees within each forest stand, (2) a macrohabitat 'local' scale represented by three stand types (pure oak stand, pure Scots pine stand, oak/Scots pine mixed stand) replicated within a given forested area and (3) a macrohabitat 'regional' scale represented by sampling in an identical manner at spatial scales (1) + (2) in two separate forests; i.e. Thetford Forest, East Anglia and the New Forest, Hampshire. We address the following specific questions in our study: 1) What is the relative importance of microhabitat and macrohabitat factors in determining biodiversity indicator species group diversity? 2) Does the diversity of the selection of biodiversity indicator species groups used in this study increase in mixed compared with single tree species stands, and are these findings repeated between different forested regions? 3) Do all biodiversity indicator species groups respond in the same way to increased levels of forest stand heterogeneity?

## Stabilizing the production function by the mixture of tree species

Dr Patrick VALLET - Cemagref - France
Dr Thomas PEROT - Cemagref - France
Maude TOIGO - Cemagref - France

The mixture of tree species can lead to increased productivity compared to pure stands composed of the same species. This has been observed in many situations, but the mechanisms that underlie it are still unknown. The complementarity of species to abiotic hazards, such as climate change, or biotic hazards, such as pests, is one of the hypotheses that could explain it. Indeed, in the case of bispecific forests stands, if one species is favored by a temporary decrease in the competitiveness of the other species, there may be growth compensation and thus a stabilization of the production function. We used data from the French National Forest Inventory to model the basal area growth of pure and mixed stands of silver fir and Norway spruce, depending on environmental conditions (climate, soil), forest management, and stage of development of the stands. These models are valid in the four mountain ranges in France in which the mixture of these species can be found: the Vosges, Jura, Massif Central and the Alps. Our results highlight on the one hand the environmental variables that affect the growth of each species, on the other hand the effect of mixture on growth. The basal area growth of silver fir is characterized by a strong influence of climatic conditions, especially the spring ones (positive effect of temperature and precipitation). The growth of Norway spruce is less plastic than the silver fir one, and more related to soil characteristics. The effect of the mixture is positive for silver fir, proportionally to the rate of mixture, but there is no effect for spruce. The outcome at the stand level is an increased productivity in the mixed stands compared to pure stands. In this talk, we present the methodology for the construction of the basal area growth models based on data from the National Forest Inventory, we detail the environmental variables that go into the silver fir and Norway spruce growth models, and we show the effect of mixture on growth for these species. Finally, we show how this methodology will be used in a PhD thesis to study how the species mixture affect the stability of the production function in the case of sessile oak stands mixed with several species with contrasting traits, particularly in relation to their response to climatic factors.

# The adaptation of French forests to climate change by species substitution

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Vincent BADEAU - INRA - France
Thierry LAMANT - ONF - France
Philippe RIOU-NIVERT - CNPF – France

Presentation of the project "NOMADE", financed by the french network "Aforce". The substitution of forest species within populations is one of the possible answers to the impact of climate change if natural adaptation of existing species and adjustment for origin are found to be ineffective. To provide answers to administrators desirous to find feasible technical reorientations to meet the expected challenges, information on possible introductions is needed rapidly. This project proposes an initial assessment of the subject in two stages. First, an assessment of the past use of exotic species in France from an economic and forestry perspective as well as from a sociological view-point. In the second stage, a census of possible species, stressing those species available in the framework of existing evaluations (tests, arboretums… ). This assessment will be compared with available knowledge of the ecology of candidate species with particular regard to pedo-climatic aspects and growth potential. Regional lists will be researched in order to best meet the demand as well as to target the regions where the decline of indigenous species already represents a risk and/or where the natural adaptive response seems most problematical. Following the /'Guide des expérimentations forestières en lien avec le changement climatique'/ the project will propose a simple experimental protocol for introductory trials for exotic species or origin. The protocol will be useable by development institutions and will be easy to repeat, and thus allow the development of a network. A pilot trial to be installed in the Centre region will serve to validate the protocol and could serve a the base for further action.

## The TRAITAUT project: functional TRAITs and AUToecology of tree species

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Climate change leads to physiological and phenological modifications of tree forest species. To assess the conditions of forest adaptation to these changes, it is necessary to describe the autoecology of tree species, defined as the species response to the environmental factors according to their respective physiologies and adaptations. Indeed, the foresters need operational tools for the selection of future species. Tree species autoecology is generally described in forest guidebooks with empirical parameters which are hardly adjustable to the climate change context. It is thus necessary to overhaul the autoecological approach by including quantitative parameters like functional traits defined as morpho-physio-phenological characteristics which indirectly impact the fitness of individuals. TRAITAUT (functional TRAITs and AUToecology of tree species) is a collective project focused on this topic. It is supported by the GIP Ecofor and the RMT Aforce and aims at: (1) clarifying the definitions and outlines of autoecology; (2) developing a new quantitative and generalizable methodology to describe the tree species autoecology by including functional traits and ecophysiological parameters and (3) providing a collaborative web portal to facilitate the exchanges and the information sources on the autoecology of tree species and functional traits.

# AFORCE, a network devoted to the adaptation of forests to climate change

Olivier Picard – IDF - France
Céline Perrier – IDF - France

A **joint R & D network named AFORCE** has been created as a response to forest managers needs that have strongly expressed a lack of **clear and precise recommendations** to anticipate climate change. It started in 2008 thanks to a financial support of the ministry for Agriculture. It is also supported today by an interprofessionnal association: "France Bois Forêt". The main target of AFORCE is to provide forests managers as soon as possible with **practical tools and guides,** to help them to make the best management choices. It also aims to create a common place favourable to **exchanges** and facilitating **skills structuring**. Such an organization will permit to **coordinate initiatives** that contribute to **gather and test available scientific knowledge**.

**More than twelve forest institutions** belonging to research, development, forest management and educational sectors are involved in the network.
**Five topics** have been defined to structure the network activity, coordinate the actions and centralize the information: forests sites, stand vulnerability, genetic inheritance, growth and forestry, socio-economy.
Since 3 years, the network organizes **annual calls for new projects**. The requested projects have to last less than 2 years and must necessarily implicate several institutions belonging to research and development. The implementation of fifteen new projects has already been supported. For the two next years, the network will organize **3 workgroups**. They will have to produce recommendations and tools on the following topics: sites diagnosis and species choice, water management in the existing stands forestry, creation and renewal of the forest stands.

Web site : http://www.foretpriveefrancaise.com/aforce

# MITIGATION

**Mitigating climate change by utilization of energy potential of Ukrainian forests**

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Annual increase of use of alternative sources of renewable energy in terms of global climate change and inevitable reduction of stocks of fossil fuels is a major task in the way of stabilization of environmental situation. Nowadays threat of global energy and environmental crisis prompts global scientific community to integration of research towards utilization of biomass energy as a strategic resource. In the new millennium these surveys have become topical in Ukraine, which is energy-dependent and have one of the highest energy consumption per unit of output in Europe, could not remain aloof to global energy and environmental problems. Ukraine, to date, has significant potential of biomass available for energy production. Involvement of the potential for energy production in the short term can satisfy 13-15% of the state's requirements in primary energy. As a result of the studies it was found that in Ukraine annual energy potential of forest biomass approximates 90 PJ, which is about 1.5% of the total consumption of all forms of energy in the country. Involvement of this potential to overall energy balance of the country by substitution of fossil fuel would reduce CO2 emissions by 2.5 million tons annually and would provide revenue to the national economy in amount of about 400 million Euros. It should be noted that about 35% of the total forest biomass, possible to use for energy purposes, is concentrated in northern, about 60% – in western and central parts of the country, and only about 5% in the south. The most advantageous from an economic standpoint is use of forest biomass energy, concentrated in the Carpathian region, as forests of Ukrainian Carpathians are characterized by the highest energy density of biomass – 457.2 kJ·(m2)-1, while in other forest growing zones these figures are much lower: Polissya – 255.8 kJ·(m2)-1, Forest-Steppe – 144.2 kJ·(m2)-1, Steppe – 36.5 kJ·(m2)-1. Currently, to ensure rational use of energy potential of forest biomass in Ukraine it is required to introduce regional target programs on replacing fossil fuel energy with biofuels that will significantly reduce carbon emissions into the atmosphere and attract additional financial resources in the regional economy.

# An economic analysis of afforestation for provision of multiple ecosystem services, with some implications for carbon forestry in Ukraine

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This paper analyses costs and benefits of planting trees on marginal lands across forestry zones in Ukraine with the purpose of using them for timber production, erosion prevention and climate change mitigation. The research reveals that establishment of new forests to increase timber production and alleviate soil erosion is economically and environmentally justified in some regions.

Afforestation in Ukraine, where the vast areas are suitable for tree-planting, is seen as a means to contribute to sustainable land management and climate change mitigation. The afforestation costs are low, apparently due to good forest growing conditions and relatively low labour costs. An expansion of forest cover is important with regard to soil protection. Annually, 1 ha of forest in Ukraine provides soil protection benefits to agriculture of €1.6 to €58.2. Such a broad range can be explained by the variety of conditions. A low share of forest cover might be among the causes of erosion and planting trees is a possible measure to alleviate it, particularly in the Steppe.

When only timber production gains and those from the protection of agricultural land against erosion are taken into account, at 2% through 4% discount rates, the benefits from afforestation are high in the Steppe, Wooded Steppe and the Carpathians, where the tree-planting is economically justified on c. 1.82Mha of land. When a discount rate of 4% is used, the planting of trees is to be limited to bare land in these zones, with the total area of 0.42 Mha.

Incorporating the effects of afforestation through on climate change mitigation increases social benefits. Climate change mitigation is an important supporting and regulatory forest function. However, with or without a consideration of carbon sequestration, at discount rates lower than 2%, the costs for afforestation will be covered by the returns in the majority of regions. The results indicate that whilst soil protection benefits from afforestation in the Steppe are expected to be high, the carbon sequestration and timber production activities are not cost-efficient due to low rates of tree growth and relatively high opportunity costs of land. The opportunity costs of land are also high in the Polissja where afforestation is cost-inefficient at 2% and higher discount rates.

# Uncertainty of soil carbon sink estimate - case Finnish GHG inventory

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## Introduction

The National Forest Inventories (NFI) serve often as a basis to estimate carbon stock change of tree biomass. According to the climate agreements, e.g. Kyoto protocol, countries are obliged to report carbon stock changes of biomass, litter, dead wood and soils. Countries may omit a a pool from the reporting, if they provide transparent and verifiable information that the pool in question is not loosing carbon. The objective here was to quantify the uncertainty of the model based estimate for soil carbon sink of mineral soils in Finland. In addition to that we wanted to evaluate if we can say in a transparent and verifiable way that our mineral soils in Finland are a carbon sink.

## Material and methods

The carbon stock change of litter, dead wood and soil organic matter pool of forest land mineral soils were estimated with Yasso07 soil carbon model (Tuomi et al. 2011). Yasso07 needs input information about initial carbon stock of soils and thereafter time series of litter input (living trees, harvesting residues, natural mortality and understorey vegetation) and weather data. Here we applied both constant (average 1971-2010) and annual weather data with Yasso07 model. The litter input was derived using biomass models of Repola (2008 and 2009) and litter turnoverrates (Liski et al. 2006) applied with tree level data of NFI measurements from 1970s to 2010. The parameter uncertainties and variance-covariance matrices of biomass models were utilised to estimate both the uncertainty biomass due to sampling and the uncertainty of biomass due to model uncertainty. Also the correlation between biomass components were assessed and utilized. The uncertainty of litter turnoverrates were assumed to be similar to that reported by Peltoniemi et al. (2006). The uncertainty of understorey vegetation litter input was assessed by simulating model predictions, using parameter uncertainties and variance-covariance matrices (Muukkonen et al. 2006).

## Results

According to the results Finnish mineral soils have been a sink of carbon constantly if we assume constant climate (i.e. temperature does not impact decompostion). Results are opposite when we apply annual weather data with Yasso07 and during warm and moist years soils are loosing carbon. The coefficient of variation of soil carbon stock change varied between 10% to 25% between years.

References

Liski, J., Lehtonen, A., Palosuo, T., Peltoniemi, M., Eggers, T., Muukkonen, P. & Mäkipää, R. 2006. Carbon accumulation in Finland's forests 1922-2004 - an estimate obtained by combination of forest inventory data with modelling of biomass, litter and soil. Annals of Forest Science 63(7): 687-697

Muukkonen, P., Mäkipää, R., Laiho, R., Minkkinen, K., Vasander, H. & Finér, L. 2006. Relationship between biomass and percentage cover in understorey vegetation of boreal coniferous forests. Silva Fennica 40(2): 231-245.

Peltoniemi, M., Palousuo, T., Monni, S., Mäkipää, R. 2006. Factors affecting the uncertainty of sinks and stocks of carbon in Finnish forests soils and vegetation. Forest Ecology and Management 232(1-3): 75-85

Repola, J. 2009. Biomass equations for Scots pine and Norway spruce in Finland. Silva Fennica 43(4): 625-647.

Repola, J. 2008. Biomass equations for birch in Finland. Silva Fennica 42(4): 605-624.

Tuomi, M., Rasinmäki, J., Repo, A., Vanhala, P. & Liski. J. 2011. Soil carbon model Yasso07 graphical user interface. Environmental Modeling and Software 26 (11): 1358-1362.

# Fantallometrik: the international platform for forest volume, biomass and carbon assessment

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Improved estimation of forest resources is a growing priority either for the assessment of bioenergy availability or for the analysis of the contribution of the forest sector to climate change. Allometric equations form the basis for the estimation of commercial volume, biomass and carbon stocks of a tree and a forest. New techniques and procedures have been developed to improve the accuracy of estimates. However, estimates are facing major constraints on the use of existing equations: accessibility, comparability, harmonization. The aim of this paper is to present the first international platform on allometric equations for volume, biomass and carbon assessment. The platform is the result of a global systematic review of all the available documents containing allometric equations in the world. The data are made available and harmonized to facilitate the assessment made by forest institutions, associations and scientific experts. The results show that large bias results from the inadequate use of allometric equations at tree and continental levels. Recommendations are provided to improve volume, biomass and carbon assessment. This plateform will facilitate the exchange of data between countries and to improve the accuracy and the greenhouse gas inventory to be reported to the United Nations Framework Convention on Climate Change.

# Importance of carbon storage in forest biomass and soils for climate change mitigation: case of Madagascar

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Deforestation accounts for more than 17 percent of today's total greenhouse gas emissions. The REDD (Reduced Emissions from Deforestation and forest Degradation) is among the recommended tool to climate change mitigation. Its purpose was to reduce this figure by assigning a monetary value to forests based on the avoided carbon emissions. To support the implementation of REDD; a number of studies in assessments of soil organic carbon (SOC) and aboveground biomass (AGB) carbon stocks were carried out in Madagascar and they embraced the main climatic and forest types and soil classes in Madagascar. Most of these studies used common methodologies as found in international researchers. Actually, local allometry regressions for AGB assessment were established as well as spectroscopy in the mid-infrared was used for SOC quantification. Data from these studies showed that both SOC and AGB were important pools of carbon stocks and depending to the pedology and climatic conditions, there were as much as carbon in SOC pool than in AGB pool. In fact, on the one hand, for the humid region, the AGB pool in primary forest contained 193±56 Mg C.ha-1 and up to 87,5±7,78 and 138,36± 54,71 Mg C.ha-1 in SOC pool in 0-30 cm and 0-100 cm respectively. In the other hand, for dry region, SOC in the 30 cm depth (40±9,16 Mg C.ha-1) was as much as carbon stock in the AGB (31±9 Mg C.ha-1) and nearly the twice in the 100 cm depth (63,89±19,26 Mg C.ha-1). Besides of these potentialities, it was shown that deforestation or forest degradation activities might reduce directly the AGB carbon stock, which was not the case for SOC pool (no significant carbon loss among the different level of forest degradation). This last might be explained by the slower mineralization of organic carbon in this pool. Following the example of the humid region: (i) AGB might change from the maximum of 193±56 Mg C.ha-1 up to zero biomass after forest fire (ii) SOC might be (for the 0-20 cm depth) 70 Mg C.ha-1 in degraded forest compared with the 79 Mg C.ha-1 in primary forest. These available data provided an important knowledge in terms of potentiality of carbon storage and reduction of emission from deforestation, which might allow them to identify their priority in environmental activities. Nevertheless, there is still more needs in carbon quantification in the REDD framework so that this tool could efficiently contribute to climate change mitigation.

# Carbon sequestration of urban trees in Hamburg, Germany- a comparison of three different biomass equations

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Cities play a major role in climate change, since urban activities are responsible for 40 to 80 % of the global CO2 emissions. At the same time cities will be exceedingly exposed to the consequences of global climate change. In recent years the role of urban trees and parks in reducing levels of carbon dioxide and other greenhouse gases in the atmosphere has been identified as an additional benefit. According to studies from the USA total Carbon (C) storage in urban trees varies between 19 300 t in smaller towns with about 136 000 trees to more than 1.2 Mio t in metropolitan areas like New York and Atlanta with 5.2 and 9.4 Mio trees, respectively. Annual Carbon net sequestration ranges from 600 to 32 200 tC per year. For Germany and Europe such estimates are not well documented but are widely available for managed forest ecosystems. While approaches for biomass estimation of forest trees are fairly advanced, operational methods for the assessment of biomass and C-stock of urban trees are of limited availability.

# Scenarios of carbon balance of forest land in Finland under the effect of different levels of wood use and climate change

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The Finnish forests are providing (on about 80 per cent of the total area) a considerable amount of wood for industrial use. In spite of active use of timber, growth has exceeded the drain during the last 30 years by more than 20 per cent. It is anticipated that due to the ongoing reshaping of forest industries the industrial use of wood will decline in the future. The use of wood for bioenergy is rapidly increasing and there are government plans to raise it to a considerable level in the future. Climate change predictions forecast increasing temperature and precipitation in Scandinavia. Changing environment will increase forest growth but on the other hand also increase rate of decomposition of organic matter that may affect carbon balance of forest soils considerably. To asses the effects of these factors to the carbon balance of Finnish forests, we combined the large-scale forestry model MELA with the soil carbon model Yasso07 for mineral soils. Peatland forests comprise ca 30 per cent of forest land, for the carbon balance of their soils we used a method based on emission factors in the same way it is done in the Finnish greenhouse gas inventory. MELA predicts the stock, growth, total drain and mortality under different scenarios of wood use; we use biomass functions and litter production coefficients to convert tree volumes to carbon and litter production from living trees. Cutting residues and natural mortality contribute to litter. The estimate of litter production is used as input to Yasso07 and peatland C balance calculation. We present estimates of carbon balance of forest land for 30 years with varying levels of industrial and bioenergy wood use and asses the effect of climate change with IPCC SRES A1B scenario that has been localized to Finland. The projections of the industrial and bioenergy wood consumption that we apply in the simulations are likely development paths (high and low industrial and bioenergy wood use) that are presented in separate studies. We analyze how the total carbon balance and its components (biomass, mineral and organic soils) are affected by wood use and climate change.

# A trading system for forest management carbon sink credits

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Environmental manager Anders LUNDKVIST - LKAB - Sweden
Dr Hans WINSA - Sveaskog - Sweden

This poster presents a proposal for a trading system with carbon sink credits. The system aims at creating financial incentives for an increased reduction of carbon dioxide in the atmosphere through growth-enhancing forest management activities. The major aim is that carbon sink credits will be able to be used by industry as a part of the obligations in EU ETS. In the shorter term, the goal is that it will be possible to use the carbon sink credits in the context of voluntary commitments on behalf of those wishing to support increased climate benefits within the Swedish forestry industry, at the same time as an increase in the supply of goods from the forest is made possible. The carbon dioxide content in the atmosphere is believed, by the world's scientific community, to be unacceptably high. Climate changes negatively impact financial growth and result in the increased costs brought about by phenomena such as drought, starvation, sickness and the expansion of the deserts, extreme weather conditions and floods. In such a context it is important to utilise all available possibilities to decrease carbon dioxide emissions. Our proposal for a system for carbon sink credits includes application guidelines, methods for the measurement of the projects' effects, a proposal for reporting requirements and a proposal for the means by which a verification of carbon sinks could function. The design of the system to create sink credits from carbon sinks is, primarily, an administrative process based on a variety of documentation established at various sub-stages. The system proposed in the report is intended to be able to support an expanded trading system, both administratively and technically, in a manner similar to the manner in which the clean development mechanism, CDM, was introduced in EU ETS. Increased forest growth implies that the fixing of carbon dioxide, carbon sinks, is greater, whilst at the same time, more raw materials can be delivered to the forestry industries and energy sector. In addition, it is probable that emission reductions from forestry management projects will be cheaper than the market prices listed for emissions trading in today's system, EU ETS. There is also a good potential for the forest management projects to be profitable, both from a financial and socio-economic perspective.

# La valorisation de la séquestration du carbone en forêt privée en France

Olivier PICARD - IDF / CNPF – France

La séquestration du carbone par la forêt gérée, comment les forestiers privés s'organisent pour monter des projets de valorisation de la fonction carbone ? a partir de résultats de la modélisation scientifique de la croissance des peuplements, les forestiers privés ont développés une méthode pour chiffrer et valoriser la fonction carbone de la sylviculture. il reste des difficultés méthodologiques à surmonter, mais le cadre de montage de projets volontaires carbone est désormais proposé.

# SOCIOECONOMIC ASPECTS OF CLIMATE CHANGE KNOWLEDGE MANAGEMENT

# Economically Optimal Adaptation of Forest Management in the Changing Climate

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The objective of this study is to develop economically optimal adaptation and mitigation strategies for managed Norway spruce stands. We will integrate advanced ecological forest growth models and climate change scenarios with economic descriptions on forestry utilizing long-term optimization of management procedures. The existing process-based growth model will be further developed to improve applicability to climate change simulations by incorporating weather extremities, soil nutrient cycling, and water dynamics. Developed forest economic model includes all the most relevant forest management actions and we will test their economic outcome while simulating the climate change with environmental parameters, such as temperature regime and water availability. Economic analysis will account for timber production, forest carbon sequestration and bioenergy as targets of forest management. Our results show that optimal timing and intensity of the stand management will change due to climate change. In the changing climate, growth of trees is increased due to favorable climatic conditions and accelerated nutrient cycling. Enhanced stand growth allows earlier harvesting, but optimal timing and intensity of the harvest operations are dependent on targets of the forest management. Results of the simulations will directly serve forest owners and forest extension services by providing information on adaptive measures and their economic expectation.

# Mobiliser les connaissances indigènes des peuples forestiers à la définition concertée et la mise en œuvre participative des stratégies d'atténuation et d'adaptation au Changement Climatique : l'expérimentation de la matrice « KerDST TM» dans des projets forestiers tropicaux en Afrique de l'Ouest.

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Au cours des dix dernières années, on a vu émerger sur le continent africain, un vaste éventail de procédures de participation des parties-prenantes autour des enjeux de gouvernance forestière mettant l'accent sur la recherche d'un mode d'action reconnaissant la diversité des intérêts (écologiques, économiques, socio-culturels, politiques), des positions éthiques et des considérations scientifiques. L'objectif au sens large est de rechercher un consensus, pour éviter que les seules décisions qui s'imposent, soient celles des experts, que les parties concernées soient d'accord ou non. Si vous n'avez pas les moyens de vous préparer un repas en fin de journée, d'envoyer votre enfant malade à l'hôpital, ou de vous livrer à des occupations que la plupart des gens considèrent comme normales, vous auriez du mal à vous demander dans un souci écologique et alors même que vous avez besoin de bois, de ne plus abattre d'arbres dans les forêts; vous vous direz : « qu'importent les forêts pourvus que j'aie du bois ». Et pourtant la protection de l'environnement doit être une affaire de tous. Dans ce contexte d'opposition entre le socio-culturel, l'économique et l'écologique, trouver des stratégies d'adaptation au changement climatique acceptables par tous se révèle plus que complexe. Il s'avère donc nécessaire de concevoir des outils technologiques capables de favoriser une « hybridation » des connaissances scientifiques à travers une combinaison de savoirs indigènes et experts dans une perspective délibérative. La matrice «KerDST TM» de délibération développée par le centre international REEDS en est un. Son principe est basé sur une démarche délibérative d'analyse confrontant des savoirs expérimentaux, théoriques, indigènes sur les problèmes environnementaux prioritaires tels que le changement climatique. Notre poster exposera les potentialités de cet outil numérique multimédia dans l'implication des populations locales à la définition et la mise en œuvre des stratégies d'atténuation et d'adaptation au changement climatique. Les expériences en Cote d'ivoire, au Burkina Faso, au Sénégal et en Madagascar seront abordées pour illustrer les perspectives d'échanges délibératifs autour des questions du faisable et du désirable qui sont d'habitude trop habillement traitées par des scientifiques sous l'angle simpliste de l'écologie moderne. Sera ainsi démontrée la possibilité de l'usage interactif et réciproque des NTIC pour aider à l'émergence des sciences indigènes dans la définition et la mise en œuvre des stratégies de lutte contre le changement climatique.

## Community forestry as a measure against climate change

Mr. KESSE, Brou - Ministry of environment and sustainable development - Cote d'Ivoire

The loss of biodiversity is probably felt nowhere more dramatically than in rural Africa, where most people depend on biological resources for their subsistence base and relies on them for their future prosperity. The Côte d'Ivoire is among the tropical countries that experienced the highest rates of deforestation. Since 1960, the country has lost about 67% of its original forest cover. According to estimates by the IPCC / IPCC, in 90 years, emissions from tropical deforestation amounted to 1.6 billion ton of carbon per year, equivalent to 20% of total carbon emissions. To create a mechanism capable of dealing with this problem, a variety of proposals to reduce emissions from deforestation and forest degradation including the extension of the network of protected areas in Côte d'Ivoire. Ecosystem services that will result (including REDD +), will eventually fund the recovery of certain forest areas. Thus, in response to the call of the decade of the forest, Côte d'Ivoire has established a program to create and protection of community forestry in connection with the implementation of REDD+ in Côte d'Ivoire. This contribution aims to present the pilot project to create a community forest called "Forêt des Marais Tanoé - Ehy (FMTE)" in the southeast of Côte d'Ivoire. Indeed, the FMTE and its unique wildlife face threats through various poaching, logging and industrial agriculture. Given the importance biological, ecological and socio-economic FMTE and given the threats to it, a pilot community-based management was initiated in September 2006 under the leadership of the Conservation Division of the support of national and international partners for the classification of the massive over 8000 ha community forest.

# The value of process-based forest models for economic assessments of greenhouse gas emission abatement in Europe

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Greenhouse gas emission abatement options from forestry play an important role in climate policy negotiations. Scientific advice for these negotiations is often based on global economic models which depict national forestry in a coarse way, i.e. through aggregated national supply functions. This paper compares such a coarse economic representation of emission abatement from European forestry with an integrated modeling approach where process-based forest models are linked to a European Forest and Agricultural Sector Optimization Model. To reduce the impact of other factors on this comparison, we use the same economic model for this comparison. In the coarse setup, forest production in the economic model is represented through a constant elasticity supply function which passes an observed price-quantity pair for the initial period and is shifted in subsequent periods according to projections in population and income growth. In the integrated setup, the same macro-economic drivers are used. However, forest biomass values are estimated through a detailed linkage to forest plot models which portray age class, management, and land quality specific forest production functions.
Authors: Uwe A.Schneider, Georg Kindermann, Raisa Mäkipää, Tapio Linkosalo, Annikki Mäkelä, Carlos Gracia, Anabel Sanchez, Joan Maspons, Werner Rammer, Stefan Schörghuber, Manfred J. Lexer, Kevin Sieck, Juraj Balkovic.

# Integrating a Eucalyptus fastigata carbon yield calculator in WEFES, a web explorer of forest environmental services

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WEFES, a web explorer of forest environmental services, has been under development in the scope of the TRANZFOR project (further details can be seen in this book of abstracts). One of the characteristics of the explorer is the ability to integrate the outputs of models from scientists which often do not want a disclosure of the code itself due to various reasons. A module prototype for WEFES was built for demonstration purposes where users can submit a hyperlink to their models written in a web language (e.g PHP). The submission has two components: The link to the model itself and a link to an xml file with the characteristics the model, describing the metadata, the arguments to supply, their limits, and the output of the model. As demonstration, a carbon yield calculator for Eucalyptus fastigata written in PHP and its description was linked to WEFES. The model inputs (PHP arguments) are temperature, precipitation and stems per hectare. WEFES interface architecture integrated the link to the model and supplied the arguments to the model. Because the model is driven by climate, climate change scenarios could be set up for the predictions. The integration of this model in WEFES demonstrated how a model can be supplied as a “service”, instead of a “stand alone” executable. The advantage of such method is that modelers have full control of their models, being able to modify them as much as they need (constant improvements) because the model is on their own servers and not within WEFES itself. In such way WEFES may serve as an interface for supplying models’ input and retrieves models’ outputs to display their results in a user friendly way and updated as much as the modeler is, thus providing scientific up to date information for decision makers in an integrated interface.

# The right trees on the wrong places? A spatially explicit approach to unravel the efficiency of the Scottish forestry regulatory framework in the face of climate change.

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On this poster we discuss a spatially explicit approach to unravel the capacity of the Scottish forestry institutional regulatory framework to help mitigate climate change. The Scottish forest regulatory landscape is defined by two main attributes; an extremely ambitious agenda to mitigate climate change through forest expansion, and a very complicated set of formal and informal rules, institutions and strategies that cross levels and scales. The first of the former attributes is directly driven by the agenda for climate change mitigation and adaptation set through the Scottish Climate Change Act (2009) that explicitly sets an objective of 80 % in C reduction by 2050. In order to achieve this objective, both the Scottish Land Use Strategy (SG, 2009) and the Scottish Forestry Strategy (2011-2014), advocate expanding forests from the present 17 % of occupied land to a final 25 % by 2050. Albeit these objectives are generically accepted at the National and regional levels, the mechanisms to effectively implement them at the appropriate local and landscape scales remain unclear. Thus, whilst the end responsibility for forest management is ultimately attributed to the land manager, mechanisms to coordinate actions and initiatives undertaken by the former are very poorly defined. This acts as a barrier against the up scaling of such individual actions, which is necessary to implement a spatially effective forest network. The lack of an adequate coordination capacity results in an institutional framework that does not help aligning societal objectives established for the National and Regional levels with individual, bottom-up-led private initiatives and actions (Lozada-Ellison, et al, 2012; http://meridian.aag.org/callforpapers/program/ AbstractDetail.cfm?AbstractID=44309). Ultimately, this leads to a series of institutional and social conflicts that represent a key impediment towards the consecution of the objectives set for climate change mitigation through forest management in Scotland (Munoz-Rojas, et al, 2012; https://elsevier.conference-services.net/reports/template/onetextabstract.xml?xsl=template/ onetextabstract.xsl&conferenceID=2808&abstractID=562767 ). In order to unravel the complexity of the forest regulatory framework and its efficiency, spatially explicit methods of analysis need to be applied (Buenemann, et al, 2011). This poster shows the results obtained on the application of a research strategy that examines the spatial efficiency of the Scottish forests regulatory framework. We demonstrate that the intentions of the SG to place "the right tree in the right place" (SG, 2010) will remain merely intentional unless spatially explicit institutional initiatives and actions are undertaken, and a much stronger degree of coordination amongst institutions and actors operating across levels and scales is effectively achieved.