



Adaptive Management for
Forested Lanscapes
in Transformation

IUFRO CONFERENCE POSADAS 2018

Adaptive Management for **Forested Landscapes** in Transformation

Edited by

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About this Conference



This conference highlights the accelerated changes imprinted in our planet within this era of the Anthropocene.

Transformation of forest use that is occurring in response to the pressures of globalization, population growth, resource scarcity and ecological degradation are part of the BIG challenges ahead. Biodiversity is essential to human well-being, but people have been reducing biodiversity

throughout human history. Loss of species and degradation of ecosystems are likely to accelerate further in the coming years. Nonetheless, global goals to reduce the rate of biodiversity loss have mostly not been achieved. It is essential to take into account ecological, economic and functional values of the landscape to improve planning and decision-making. Operational solutions are needed to reconciling biodiversity conservation in the light of increasing demands of natural resources and land.

Within this framework, this Conference will focus on key topics to assess problems but also to find solutions for a better future in forested landscapes.

Conference Topics

1 Human-nature relationships to support sustainable forested landscapes.

This topic analyses the transforming historical relationships between human populations and nature to support sustainable forest landscapes. It includes:

- Examples and suitable frameworks to implement planning at landscape level to achieve a win-win situation among different landscape values.
- Assessment of the capacity of forest landscape to simultaneously produce different landscape values: suitable habitats, economic returns and ecosystem services.
- Analyzes of trade-offs among the landscape values using multi-objective optimization for alternative forestry management regimes.
- Supporting ecosystem services in urban and peri-urban forests.

2 Tools, methods and approaches oriented towards solutions.

This topic welcomes examples and experience of innovative approaches of interdisciplinary research and practice that used a mixture of remote sensing, field data and biodiversity related databases that require ecologists, biologists, modellers and remote sensing experts to collaborate closely with the newest capabilities and coupling modelling methodologies.

3 Global change, vulnerability and adaptive management of forested landscapes – how to manage biodiversity threats?

Forested landscapes are affected by multiple uses and are influenced by drivers operating at different scales (i.e., from local to global) that accelerate its transformation. How to manage forested landscapes in transformation to satisfy different and sometimes conflicting goals (wood harvesting, recreation, livestock production, ecosystem services) is the pressing question in many parts of the world. This topic aims at gaining fundamental insights and experience of applications to real-world practice and transformation—to enable the integrative management of functional diversity to ultimately target measures and solutions that can better tackle the management of diverse ecosystems and forested landscapes. Particular interest is based on the understanding of different patterns of temporal β diversity to detect species loss and changes in community and functional composition, including patterns of species dominance in forested landscapes.

4 Socio-ecological approaches integrating ecosystem services and forest management.

Socio-economic information and analysis are critical inputs for designing forest conservation policies. This topic aims at expanding the frontier of knowledge on the theoretical and applied socio-economic research regarding forest management and conservation.

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Topic 1

**HUMAN-NATURE RELATIONSHIPS
TO SUPPORT SUSTAINABLE
FORESTED LANDSCAPES**

Session 1.1

Biodiversity islands: pockets of protected land in human dominated environments

Chairs: Florencia Montagnini, Brett Levin and Kjell E. Berg

THE WAY FORWARD: CONSERVING, ENHANCING AND FACILITATING BIODIVERSITY

Kjell E. Berg*

Biodiversity conservation is in great peril with significant gap in what is available and what is needed for financing Conservation in a feasible and tangible way. Several international and local organizations are involved in a variety of coordinated efforts; however, close monitoring of their results is needed to ascertain the positive impacts of such efforts. Biodiversity is not easy to finance, however it can be financed through strategies that protect other resources such as water or carbon. When businesses and communities recognize these integrated benefits as essential to their own supply chains, resource bases, and human health, financing becomes more tangible. Private capital may be able to cover the funding gap in biodiversity conservation; however, outside of philanthropy, private capital is serving its own commercial interests. More widespread holistic goals that are carried on by international agreements and organizations are the Aichi Targets developed under the framework of the Convention on Biological Diversity (CBD). These are grouped under 5 Strategic Goals and comprise 20 ambitious targets.

A couple of examples are presented here to show these difficulties. For example in China, assessments have found that all ecosystem services have increased between 2000 and 2010 (except for biodiversity habitat). Under this scenario some ecosystem services are provided except for preserving and conserving biodiversity. A most important function of these programs should be to preserve biodiversity which is not currently achieved under these scenarios. The Choco region in Colombia, a very highly diverse area, with some of the oldest most diverse forests in the world, has been partially decimated and should now be guarded against further damage at a cost shared worldwide. Taxes levied, in many jurisdictions, on activities detrimental to ecosystems worldwide should share the costs of carbon storage and the many environmental services that biodiversity islands and preserves provide.

Keywords: *Private capital, financing CBD, aichi targets.*

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PERFORMANCE OF PLANTED NON-PIONEER NATIVE TREE SPECIES IN OPEN FIELDS, YOUNG SECONDARY FORESTS, AND RUBBER PLANTATIONS IN BAHIA, BRAZIL

Daniel Piotto*

The Atlantic forest (Mata Atlântica in Brazil) is a biodiversity hotspot that has only less than 12% of its original area remaining today. In the Mata Atlântica, non-pioneer tree species (NPTS) with limited dispersal are the most impacted by the current habitat loss and fragmentation. The main strategy to conserve NPTS has been the creation of protected areas that include the last remnants of old-growth forests. However, these islands of forests may not be enough to sustain viable populations of NPTS, because of the small size of the forest remnants and lack of specialized dispersers. As some attempts to establish NPTS in pastures and agricultural fields have been failing, restoration strategies that consider other essential factors besides light, such as grass competition and site degradation may be more successful. Here, we compared the performance of planted seedlings of NPTS in open areas, young secondary forests, and within rubber plantations. Five native NPTS listed in the IUCN Red List or IBAMA Threatened Species List and two pioneer tree species were planted in April 2009 in complete randomized blocks, with four replications and four treatments. Survival, height, and dbh (diameter at the breast height) were measured every year. Mixed models were used taking block, treatment and year as fixed and species as random effects. We found higher survival of NPTS in young secondary forests and

within rubber plantations than in open fields. However, height and diameter growth was significantly higher in open fields. The trade-off between high growth and low survival poses an important question about the most feasible strategy to increasing populations of NPTS in degraded landscapes. We conclude that enriched young secondary forests and tree plantations could be important contributors to conservation of biodiversity as they can serve as nurses for endangered native tree species.

Keywords: *Plantation; endangered native tree species; Mata Atlântica.*

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SUCCESSFUL COMMUNITY FOREST MANAGEMENT WITHOUT FORMAL OWNERSHIP RIGHTS: A FUZZY-SET QUALITATIVE COMPARATIVE ANALYSIS OF TWELVE VOLUNTARY FOREST MANAGEMENT INITIATIVES IN THE PERUVIAN AMAZON

Marieke Van der Zon*

In the Peruvian Amazon, many examples exist of indigenous and migrant communities that protect their forests. Often, they do so independently of government policies and external financing. Their main motivation is to protect the ecosystem services they derive from the forests, such as water supply, ecotourism, timber and NTFPs. Few communities also protect the forest for its intrinsic biodiversity value.

While some communities have a land title, most protect forests that are officially state-owned. This is surprising given the consensus in the literature regarding the importance of tenure security for successful forest management. It is often assumed that such tenure security must be provided from the outside, through government action. This paper applies fuzzy set Qualitative Comparative Analysis (QCA) to conduct some cross-systematic comparison on twelve CFM initiatives in the San Martín, Amazonas and Loreto regions. Their forest ownership status ranges from completely informal to completely formal, and includes internal agreements, co-managed municipal conservation areas, conservation concessions, and private conservation areas.

We conclude that formal ownership rights, i.e. land titles, are by no means indispensable for successful community forest management. In addition, forest management in communities with strong ownership rights is not always successful. When formal ownership rights are ‘paper titles’ that are not accompanied by strong enforcement mechanisms, they do not contribute much to tenure security. In communities with and without formal ownership rights over the forest, strong monitoring and sanctioning mechanisms aimed at enforcing formal or informal property rights are essential for avoiding deforestation. Communities with a combination of (1) robust community enforcement and (2) either good access to government sanctioning (GS) or strong formal ownership (FO) tend to successfully protect the forest.

Keywords: *Tenure security, CFM, local enforcement, Amazon.*

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THE ROLE OF COMMUNITY LED ACTIONS FOR THE CREATION OF BIODIVERSITY ISLANDS

Brett Levin*

Biodiversity Islands are areas of protected ecosystems within a human dominated landscape. Community led action can advance the development and perpetuity of Biodiversity Islands. Through the empowerment of traditional biodiversity conservation practices, grassroots community action, and the utilization of legal tools such as conservation easements, community led conservation and community led management can protect intact sections of land where plants and animals can thrive without ecologically degenerative interference from human activity.

In many instances, traditional community based approaches include biodiversity enhancing outcomes, some of which mirror a landscape structure that may be framed as a Biodiversity Island. We intend for the term Biodiversity Island not to be an appropriation of indigenous and traditional biodiversity conservation practices, but to highlight the outcomes and understandings around these practices to advance appreciation and empowerment of such systems. Examples include sacred sites such as the Mizoram sacred groves in Northeastern India, sacred pools called *Íbú ódó* protected by Tchabè communities along the Ouémé and Okpara Rivers of Central Benin (West Africa), sacred cacao groves of the Maya, and other sacred groves in Zimbabwe, Ghana, Thailand, China, and Nepal. Likewise, other community protected sites can serve as Biodiversity Islands. For example, the village forests in Indonesia, known as *Hutan Desa*, are legally recognized for the ecosystem services and benefits to society they provide. Their management and protection are guided by traditional communal governance.

Grassroots community action and legal tools such as conservation easements through partnerships with non-profit Land Trusts can also aid in the development of Biodiversity Islands. Examples of grassroots efforts for the advancement of conservation practices are numerous, diverse, and worldwide. Legal frameworks, methods of enforcement, modes of implementation, and levels of community engagement are site and context dependent, but through these efforts of community led action, Biodiversity Islands may be protected and managed through time.

Keywords: *Community led conservation, community led management, sacred forests, grassroots action, conservation easements, land trusts.*

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MICRO-TOPOGRAPHY ASSOCIATED TO FOREST EDGES

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Forest edges are often defined as the discontinuity between the forest habitat and an adjacent open habitat, thus they are based on a clear difference in the structure of the dominant vegetation. However, beside this very general definition, in the field we can observe a large diversity of edges, with often different kinds of micro-topography features: bank, ditch, stone wall, path, etc. As these elements are rather common in many temperate forest edges, it seems important to start to characterize them more clearly and with consistency. From a set of observations in south-western France, we build a first typology of the micro-topographic elements associated to forest edges. For each of them we describe the process, natural or human induced, at their origin, and according to the literature available, we identify some of their key ecological roles. Banks, generated by the differential erosion between forest and crops along slopes, are especially analyzed since they are

the most common micro-topographic element in our region. It offers many micro-habitat conditions in the soil used by a wide range of species, notably by several bee species. More research is required to study in details the importance of such micro-topographic elements.

Keywords: *Forest edge, micro-topography, biodiversity.*

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CONSERVATION, CONNECTIVITY AND REGISTRATION OF SEED AREAS IN REMNANTS OF NATURAL RESERVES IN THE PROVINCE OF MISIONES, ARGENTINA

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The eco-region of the Atlantic Forest in South America is one of the 35 biodiversity hotspots. In Argentina, the Atlantic Forest of Alto Paraná emerges from the coast and shares portions with Brazil and Paraguay. In the Province of Misiones, the Selva Misionera or Selva Paranaense harbours the greatest biodiversity in Argentina. Restored areas of protective forests on margins of streams and slopes provide connectivity for diversity for the basins of the Uruguay, Iguazú and Paraná rivers. In Misiones national and provincial laws demand and promote restoration of degraded areas, which requires propagation material of native species. A registry of forest areas and seed trees is currently being implemented nationwide to serve as repositories of biodiversity and plant propagation material. In these areas, which can be in private lands as well as in national parks or reserves, all the plant propagation material is certified. Priority is given to the registration of arboreal species, with a special focus on rare, endemic, threatened and / or vulnerable species. A technical sheet is prepared for each tree including data on its size, location, health, habitat, and photographs. A list of all selected individuals and diversity of plant species, including epiphytes, lianas, ferns, herbs and shrubs is prepared for each registered area. Each species is registered in every site where they occur so as to include as much genetic variability as possible. The certification of propagation material establishes a protocol that allows native species to be included, under a certified control, in sustainable productive and multiple-purpose use systems (firewood, wood, medicinal, ornamental, honey, food, others). The certification of the massive use of native species for multiple use purposes is a contribution to their conservation and generates resources for owners who are currently conserving biodiversity.

Keywords: *Conservation, biodiversity, native species, propagation, certification.*

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BIODIVERSITY CONSERVATION; EXAMPLE OF AN EKURI COMMUNITY FORESTRY INITIATIVE IN NIGERIA IN THE MANAGEMENT OF NATIVE FOREST AND FORESTRY LANDSCAPES

Edwin Ogar* and Louis Agbor

Ekuri community: The Ekuri community, with a population of 6,000 people, consists of Old Ekuri and New Ekuri villages in Cross River State of Nigeria, and owns 33,600ha of primary forest, the largest communally controlled forest in Nigeria. In 1992, the Ekuri community established the Ekuri Initiative, an NGO with a mandate in management of native forest, forestry landscapes for biodiversity conservation and livelihoods.

The Ekuri community's passion, efforts and commitments is recognized nationally and globally as a pacesetter in Nigeria in biodiversity conservation as 90% of her forest is still primitive. The following strategies are used to achieve these successes:

- a) Perimeter Survey: In 1996, the Ekuri community implemented a perimeter survey (33,600ha) to enable them know the actual forestland size in their possession and how to plan to use it wisely.
- b) Land use plan: In 1999, the community implemented a land use planning and created 8 designated zones namely: farming, riparian, protected areas, timber management, NTFPs, cash crop, wild life corridor, etc. Protected areas accounts for 50% of total forest size.
- c) Timber of 70cm diameter and above are harvested in a 50 inventory plot in the timber zone leaving immature timber to grow to maturity for harvesting in 40 years and allowing "mother trees" un-harvested to fruit and reseed the forest floor.
- d) The communal bye-laws established enables individual households to harvest NTFPS for domestic uses or incomes while restricting commercial harvest of timber to the Ekuri Initiative though individuals have rights to harvest timber for domestic uses only. This law forbids individual ownership of trees on farmlands and in the forest but by the community. This forecloses forest degradation through individuals' harvesting of commercial timber.
- e) Others are sustainable harvesting of NTFPs, capacity building, collaboration with government/NGOs, funders, regular reconnaissance of forest, enforcement and sanctions.

Keywords: *Biodiversity, conservation, community, land use plan, partnership.*

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THE CONTRIBUTION OF AGROFORESTRY SYSTEMS TO RESTORATION AND CONSERVATION IN BIODIVERSITY ISLANDS

Florenca Montagnini*

Biodiversity Islands are areas of protected ecosystems in human dominated landscapes. Agroforestry systems (AFS), which combine trees and crops on the same land, can increase productivity and are also biodiversity friendly, bringing social, economic and environmental advantages to the farmer and society. Due to their capacity for harmonizing production with environmental values such as biodiversity conservation, AFS are often important components among land uses in buffer zones of protected areas. Thus, AFS can be a great tool as component parts of biodiversity islands.

This paper shows how AFS can be integrated in the design of Biodiversity Islands. The specific characteristics of AFS vary strongly according to system design, objectives, and species involved. Therefore the environmental services of AFS can vary, and caution should be taken when deciding on design and management of AFS to be included as component parts of biodiversity islands. The contribution of AFS to biodiversity depends on the type of AFS, its management, component species, and position in the landscape matrix. The traditional, low intensive management multistrata AFS with native species has the greatest potential to harbor the largest biodiversity. As management intensity increases, biodiversity decreases accordingly. Several approaches have taken lessons from the traditional systems mimicking natural forests and successional patterns, in multistrata forests which may be integrated within biodiversity islands or create the buffer zones.

Guidelines are offered here for help in designing and managing AFS to increase their value for biodiversity. As a component of biodiversity islands, traditional, indigenous land uses have the greatest value as contributors to biodiversity conservation and may make up the Biodiversity Island, whereas more intensively managed AFS may be part of buffer zones. No matter the scenario, the inclusion of AFS within the design of biodiversity islands provides greater biodiversity than conventional monoculture agriculture/forestry or degraded landscapes.

Keywords: *Agroforestry design, buffer zones, indigenous systems, management, multistrata.*

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CONTRIBUTION TO THE DOMESTICATION AND CONSERVATION OF THE GENETIC DIVERSITY OF TWO NATIVE MULTIPURPOSE SPECIES OF MISIONES – ARGENTINA

Patricia Rocha*, Ricardo Buchwies, Peggy Thalmayr, José González,
Florencia Montagnini and Fernando Niella

It is important to ensure that trees in remnants of forests across landscapes, which can serve as biodiversity islands, have high genetic diversity so that these forests can persist through time adapting to disturbances. In Misiones (Argentina), the selective logging of timber species, based on the Minimum Diameter Cutting (MDC) limit, established by provincial legislation, has generated degraded forests with isolated trees and open spaces without tree cover, where bamboos have invaded, preventing natural regeneration. The intensity of forest exploitation methods can modify the growth patterns of the residual trees and lead to an increase of inbred seeds, which compromise the population as a seeds source. These forests can be restored using enrichment planting to increase their value for biodiversity. The present work describes our strategy, aiming to the preservation and production of propagules with high genetic diversity of two native species, *Peltophorum dubium* and *Enterolobium contortisiliquum*, which are good candidates for forest restoration or enrichment projects. These two species are of interest not only to the forest industry due to the quality of their wood, but also to fauna as they are both melliferous. Previous research has shown they are suitable for restoration of degraded areas, consociated agro-livestock or silvicultural systems. Progeny and clonal trials as well as clonal gardens were established in enrichment strips and in open plantations. To date, the results obtained from short-term trials in the nursery, and from one year-old field enrichment strips, showed statistically significant differences between the provenances and progenies on germination capacity, survival rate, height and DNH (Diameter at Neck Height), with an average survival of 93% for both species. These results suggest adaptability to site, clonal propagation capacity and potential for restoration programs on biodiversity islands using these two multipurpose species.

Keywords: *Peltophorum dubium, Enterolobium contortisiliquum, progeny, provenance, miniclinal gardens.*

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BALANCING BETWEEN LIVELIHOOD SECURITY AND ENVIRONMENTAL CONSERVATION: THE EXPERIENCE OF RURAL HOUSEHOLDS AROUND TURFLOOP NATURE RESERVE, LIMPOPO PROVINCE, SOUTH AFRICA

Isaac B. Oluwatayo*

There is no gainsaying the critical role that forests play in the lives of poor households, especially with the burgeoning threats of climate change and worsening socioeconomic status of many households in South Africa. This is attributable to the increasing contributions of forests and forest products to the livelihood security of households either in terms of income generation or as a source of food. Despite this pivotal place of forests in South Africa, there is a challenge of balancing between its livelihood security potential and ensuring that the environment is not affected considering the rising wave of climate related problems in the country. This study therefore examines how households living around the Turfloop Nature Reserve harness it and also ensure that the environment is not hampered. Data for this study were collected from a random sample of 120 households in the study area. Analytical methods employed include descriptive statistics, FGT poverty index and probit regression model. Analysis of respondents' socioeconomic characteristics revealed their average age to be 56 years with more women than men. Respondents' distribution by education showed that about one-third had no formal education with an average household size of 5 members. Poverty analysis showed that about 72 percent are poor with women poorer than their men counterpart. The result of the probit model performed to ascertain some correlates of harnessing forests and forest products for livelihood security revealed gender, household size, poverty status, educational status and access to credit as key factors. Some of the measures taken to minimize their impact on the Nature Reserve include proper waste disposal, rotational exploitation and awareness creation on management of natural resources among others. The study suggests provision of employment opportunities by government and other relevant stakeholders to reduce forest dependence. Also, capacity building of households through education.

Keywords: *Turfloop Nature Reserve, forest, South Africa, trade-off, wellbeing.*

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Session 1.3

Balancing environmental, productive
and welfare needs towards a
sustainable forest management
approach in Mesopotamia, Argentina

Chair: Gustavo Zuleta

SOCIO-ECOLOGICAL APPROACHES INTEGRATING ECOSYSTEM SERVICES AND FOREST MANAGEMENT

Chinyere Hannah Dickson*

The concept of sustainable forest management is based on the principle of ecological sustainability and sustainable yield. Sustainable forest management integrates consideration of biodiversity, ecosystem health and vitality, ecological productivity, and socio-economic sustainability within a framework of intergenerational equity and a precautionary approach to forest management. Biodiversity provides the essential underpinning for ecological, social and economic sustainability typically provided in the form of ecosystem services. The concept of ecosystem services is incorporated within the principles of sustainable yield; whereby the production of goods, provision of regeneration and stabilizing processes for ecosystems, life-fulfilling functions and preservation of opportunities to generations of human societies are implied and assumed.

Keywords: *Sustainable forest management, ecosystem health, ecological productivity, socioeconomic sustainability*

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ARE GOOD PRACTICES OF ARGENTINA'S FORESTRY PLANTATIONS GOOD ENOUGH TO PREVENT ENVIRONMENTAL DEGRADATION?

Gustavo Zuleta*

Despite early warnings during the '60s, degradation of natural resources is still a relevant concern worldwide. About 70% of the terrestrial vegetation cover is currently modified from natural conditions and thousands of wildlife species were extirpated from most of their historical geographical range and face high risk of global extinction. In 2018, conservation, restoration and sustainable use are still relevant goals to improve ecological conditions but not enough. Environmental impact assessments (EIAs), the first legal tool established in 1969, failure to revert degradation. EIA became more a permitting, bureaucratic issue to satisfy the economic and engineering needs of development projects rather to control or modify them. Business certification and other management systems (e.g. ISO, FSC), set up since the '90s, claim to guarantee "good practices". However, their effectiveness is also questionable. Under this context, I intend to answer the title's question of this presentation by reviewing how the forestry sector fulfills the classic environmental paradigm. I also propose which "good practices" are more necessary to properly achieve sustainability based on the best available knowledge and recommendations from 18 multi-sectorial workshops held in Mesopotamia during 2005-2015. Priority measures are: (1) to establish natural protected areas in order to preserve at least 17% of each ecoregion historical area (or major ecosystem type), (2) minimize or avoid land uses in zones with high conservation values or low protection (e.g. grasslands, riparian habitats, wetlands), (3) establish or facilitate connectivity at multiple scales, (4) preserve wildlife species threatened to extinction, (5) integrate existing regional networks of participatory monitoring (open science programs), and (6) estimate cumulative and synergic impacts. The effectiveness of these measures

requires that forest companies accept their social and environmental responsibilities are beyond the limits of their ownership. In fact, they are also valid for the agriculture and livestock sectors of Mesopotamia.

Keywords: *Environmental governance, effective measures, ineffective practices, biodiversity conservation, landscape planning.*

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LAND USE AND LAND COVER (LULC) DYNAMICS AND THEIR RELATIONSHIPS WITH FOREST AND SOCIO-ECOLOGICAL TRANSITION MODELS IN MESOPOTAMIA, ARGENTINA

Victoria E. Espinoza-Mendoza* and Gustavo Zuleta

The detection, analysis of LULC dynamics and identification of drivers of ecosystem degradation are fundamental for conservation, restoration and sustainability use. Understanding changes is key to assess the historical transitions in the landscape through the term "land sharing". The point at which forest decline halts and begins to rise, is called Forest Transition (FT), and is closely linked to LULC dynamics, but not usually addressed. Several theories have been proposed that a FT occurs during the course of long-run economic development. Similarly, the Socio-Ecological Transition (SET) is focused on spatial interactions between human society and ecosystems. The Mesopotamia region is a mosaic of mixed realities covering around 20Mha including a significant eco-regional gradient from temperate grasslands, subtropical forests, wetlands and open, dry forests. Linked to this, the economic and social effects are closely associated to a SET at the landscape level. Major LULC changes over recent decades have exacerbated the degradation, being Espinal and Pastizal Pampeano the most disturbed ecoregions (around 70%). Under this context we reviewed the scientific literature about how these models applied in Mesopotamia. We found that: (1) Selva Paranaense exhibits a delaying FT due to barriers such as local, economic and political factors; (2) Campos and Malezales is characterized by a replacement of native grasslands under livestock to exotic forestry; (3) Espinal shows an FT pattern: the forest was transformed into grasslands and later replaced by croplands and this land use type finally transformed into forestry; (4) Pastizal Pampeano follows the Pampean economic model ("Pampeanización" Spanish acronym, in reference to the most populated and developed ecoregion of Argentina), and (5) Delta del Paraná presents a mixed model influenced by exotic invasions and alteration of the hydrodynamics to facilitate forestry. Finally, we consider that FT overlaps with the classic LULC dynamics and does not apply totally to explain transitions and LULC changes in our study area.

Keywords: *LULC drivers, Pampeanización, forest transition, socioecological transition, landscape planning.*

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SUSTAINABILITY AS A MEETING POINT: INTEGRATING THE GOVERNANCE, BUSINESS AND SOCIAL SECTORS WITH BIODIVERSITY CONSERVATION OF THE MESOPOTAMIA REGION

Daniela Abarca* and Gustavo Zuleta

Argentina, in concordance to world trends, shows rapid LULC changes that exert detrimental and adverse impacts to nature and human well-being. The Mesopotamia region (NE Argentina) in particular, constitutes a heterogeneous landscape of 20Mha that combines a history of land uses and a variety of socio-cultural and economic realities. It has endured continuous replacement of natural lands (or habitat loss) by the agroforestry cattle industry and specifically it's where 79% of the country's forest plantations are located and where production has increased the most. NGOs, public organisms and several scientific-technical institutions together with the productive sector are actively engaged stakeholders that have contributed with valuable scientific and technical information to shorten the gap between science, policy and implementation. Therefore, the analysis of the environmental dimension of land use requires multidisciplinary and complex approaches at several scales.

Based on a long-term, multi-scale program to improve sustainability that we've developed in the region since 2005; we can argue that the main driver of regulatory frameworks and cooperation among stakeholders is the individual (or specific sector) initiative. Given this context, we question how can different conceptual frameworks, legal tools, policy instruments, management strategies and experiences be combined to achieve sustainability? how can effective conservation strategies, productive management and human welfare be achieved while sustaining the forested landscapes and their biodiversity? To achieve this, it's necessary to project a sustainable reality for the region and to encourage a blended approach for an integral, multidisciplinary framework and solutions. It's clear that our next challenges are mainly from the social and political dimensions: to take decisions in the right directions.

Keywords: *Sustainability, biodiversity, interdisciplinary approach, integral dimensions.*

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TOWARD THE PERPETUITY OF MISIONES' BIODIVERSITY, CULTURE AND SUSTAINABLE DEVELOPMENT

Juan Gauto*

The province of Misiones extends over 3 million hectares and is currently the best example of Atlantic Forest in the region. But, how is this even possible after 150 years of Western agricultural colonization? We find answers in the edaphic and orographic features of the territory, and in strategic commercial migratory currents. Misiones' soils have an excellent physical structure and depth which, combined with favorable climatic conditions, result in an optimal region for commercial farming, especially of trees. An exception to this is the Eastern area of the province (Uruguay River basin), whose slopes and topographic complexity hinder the use of farming machinery. Until the mid of the 20th century, the region was predominantly used for small-scale Western agriculture, with medium to low levels of technological complexity. This acted as a cultural barrier, preventing a higher degree of degradation of natural systems —namely the conversion of forests to agricultural lands. When Misiones acquired the status of province in 1953, a series of new regulations —such as laws, decrees, and municipal bylaws— bestowed natural resources a legal entity status. Simultaneously, cultivated forests were brought to the region as a strategic resource for the pulp and paper industry. This phenomenon, however, created tension due to high-density plantations that lacked biodiversity, and was limited by social resistance to

novel agro-systems based on a high technological approach. Decades later, the coexistence of biodiversity with commercial —agricultural and silvicultural— diversity is evidenced by reflective local and global societies that strive to work toward the perpetuity of Misiones' biodiversity, culture, and sustainable development.

Keywords: *Western agricultural colonization, biodiversity conservation, technological complexity, governance, social issues.*

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VISION OF A FORESTRY COMPANY REGARDING TIMBER PRODUCTION AND ENVIRONMENTAL CONSERVATION

Germán Becerro*, Cyntia Almada and Raul Pezzutti

Forestal Bosques del Plata S.A. (BDP) is a company with 25 years of activity in Northern Corrientes province and Southern Misiones province. Its patrimony is composed by forest production areas implanted with *Pinus taeda*, *Pinus elliottii* and *Pinus caribaea* var. *hondurensis*, and preservation areas of native forests, grasslands, weeds, wetlands and watercourses. The plantations are managed under various combinations of pruning and thinning schemes to produce logs, sawn wood and wood pulp. Following a culture of production and respect for the environment, the company conducted an Environmental Impact Assessment study (EIA) of its activities and in 2006 implemented an Environmental Management System (SGA, by its Spanish acronym) certified under the ISO 14001 standard. Therefore, BDP established its activities within the framework of its social, environmental, safety and occupational health policy. In order to integrate production and Nature's conservation a comprehensive biodiversity management plan was developed based on the determination of conservation values at different scales (local to regional, wildlife species and landscape integrity). Finally, 6 Areas of High Conservation Value (HCV) in grassland and native forest environments were identified. In an effort to achieve sustainability and provide ecological connectivity, the company protects circa 19.055 ha of natural environments (20% of the total area). The SGA allowed to identify and evaluate the environmental impacts of the activities carried out during the forestry production and to undertake the required actions to avoid and/or mitigate them. Specific studies and continuous monitoring of fauna, water, flora and soil are being developed through association with public and private institutions such as Maimónides University, UBA, UNaM-FCF, UNaM-FCEQyN, UNNE, USAL, UFSM, IBS, CECOAL, CONICET, INTA, among others. Its results are used to monitor and evaluate the state of natural resources over time, and to continuously improve operational practices to assure an adequate environmental performance.

Keywords: *Forestry, Areas of High Conservation Value, timber production, environmental conservation.*

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SUSTAINABLE FORESTRY MANAGEMENT IN PRODUCTIVE LANDSCAPES MULTI-SCALE STRATEGIES BY ARAUCO ARGENTINA

L. Rivero, M. Romero, P. Cortez and B. Hauri*

Societal development requires goods and services supplied not only by production activities, but also by natural systems. The balance between these two must be reached through social consensus

at the landscape scale. Sustainable forestry management is defined as the administration and use of forests and forested landscapes in a way and at a rate in which it is possible to maintain their biological diversity, productivity, regeneration potential, vigor, and capacity to provide present and future ecological, economic, and social functions. The “sustainable” concept, applied to planted forests, is key to the silviculture of forestry lands. Given that protected areas are not enough to conserve all species and ecosystem functions, productive landscapes must be approached from an interdisciplinary point of view where management targets both species and productivity. This is achieved by means of a management model at the landscape scale, which enables the integration of production and ecosystem service conservation in a context of social consensus. This type of management includes land use zoning, social and environmental monitoring, internal and external communication schemes, and the generation of opportunities for debate and consensus with the communities. As an example of this, Arauco protects nearly 120.000 hectares of forests, grasslands, and wetlands (including 47 High Conservation Value Areas); develops conservation, research, and recreation activities; carries out an annual monitoring of flora, fauna, soil, and water; involves stakeholders in various participatory activities; and, is in permanent interaction with 33 Mbyá Guaraní communities.

Keywords: *Productive activities, conservation of ecosystem services, landscape scale, sustainable forest management, social consensus.*

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COMPARING ATTITUDES TOWARD FORESTRY PLANTATIONS AND FOREST INDUSTRY IN SELECTED COMMUNITIES OF CORRIENTES, MISIONES AND BUENOS AIRES

Diana Diaz*, Laura Gervasi, Claudia Peirano and José Loíacono

The Argentine region Mesopotamia contains 79% of the forestry plantations of Argentina. In contrast with growth of the wood supply capacity, investment in forest industry has not followed the same trend. Public concern about environmental impacts was one important issue —among others— discouraging investment in forest industry.

Based on the conceptual model Values-Beliefs-Norms-Behavior of environmental psychology and applying methods of the empirical sociology, we asked for stated attitude and we determined estimated attitude towards forestry plantations and forest industry among selected groups in Misiones (population of three departments, N=739), Corrientes (also three departments, N=603) and Buenos Aires (two groups, N=47 and N=31 respectively). Beliefs about contributions of the forestry sector to environmental, economic and welfare needs as well as environmental concern related to forestry activities were included in order to estimate the cognitive components of attitude.

Differences in attitudes toward the sector were found between groups, with higher proportion of respondents in Misiones stating negative attitude toward forest plantations (22.8% in Posadas) and forest industry (28,1% in Posadas). In contrast, in Corrientes capital 4.7% and 12.1% of respondents reported negative attitudes to forestry plantations and industry respectively, while in Bs. As. Results were variable between groups. We also found that persons indicating negative attitude towards forest industry were also more willing to take actions against their installation.

Between groups, beliefs about environmental, economic and social contributions of the sector and concern about environmental impacts by plantations and forest industry showed similarities (e.g. sector’s contributions in providing useful products for society; employment numbers) as well as differences (e.g., perceptions of impacts on water quantity and quality; employment quality).

Our findings can be applied to a better understanding of differences in attitudes between groups of the society, improve the dialogue between the sector and the public and contribute to sustainable forest management.

Keywords: *Forestry plantations, forest industry, attitude.*

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STAND MANAGEMENT AND WATER FLOWS IN *PINUS TAEDA* L. IN ARGENTINA

Raul Pezzutti*, Silvana Caldato, Javier Gyenge, Raul Schenone and Pedro Sansberro

The knowledge of water flows in forest plantations is a support tool for decision-making. The aim of this study was to characterize the water flows in a *Pinus taeda* plantation, in the northeast of Argentina. In 2015 when the investigation began, the stand was 8 years old with a density of 863 trees ha⁻¹, at 9 years of age was carried out a thinning leaving 363 trees ha⁻¹. The sap flow was evaluated in 26 trees and 32 sensors by Granier's thermodynamic method. The distribution of rainfall (bulk precipitation) into throughfall, stemflow, canopy interception loss and litterfall retention was analyzed by the installation of rain collectors in different positions. Dendrometric variables were measured monthly to determine water use efficiency. Transpiration was related to tree size, with an average of 12 and 50 liters of water per day for individuals with a DBH of 15 and 35 cm, respectively. The *Pinus taeda* crown intercepted 24.2% of the global precipitation in unthinned situation and 17.2% in thinned situation. In 2016 the annual precipitation was 1677mm, 589 mm were used for transpiration and 1034 mm for total evapotranspiration of the stand, resulting in a positive water balance of 643 mm (38%). In 2017 the annual precipitation was 2581 mm, the water balance was positive in 1602 mm (62%). The average transpiration per tree per day was 28 liters, depending on the time of the year and the diameter of the trees. During the spring and summer, the highest values of transpirations occurred. The water balance was positive, influenced by the regime of rainfall and the management of the plantation. The water use efficiency for wood production was 868.1 L kg⁻¹ of dry mass. The results allow to consider that the *Pinus taeda* plantations are compatible with the environmental conditions of the region.

Keywords: *Pinus taeda, transpiration, water balance, water use efficiency, sustainability.*

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Session 1.4

Environmental education for
biodiversity and ecosystem
services conservation

Chair: Víctor Ávila Akerberg

CHARACTERIZATION OF MANGROVE SPECIES FROM THE PRESERVED WOOD COLLECTION

Taimy Jiménez Enriquez*, Katya Manzanares Ayala and Digna Velázquez Viera

The recovery of the mangroves is a priority activity because they are contemplated in the Life Task. In the study, an examination was made of the samples of the species of this ecosystem deposited in the Julián Acuña Gale Xiloteca, of the Institute of Agro-Forestry Research. The objective of the work was to describe the state of conservation of this collection. It was found that the three typical species are represented in the sample and *Avicinia germinas* (mangle prieto) was the taxa with the largest number of individuals inventoried for a relative abundance of 0.65%, while *Laguncularia racemosa*, *Conocarpus erestus* and *Rizophora mangle* present depressed populations. It was determined that the average cross section of the specimens is the one with the highest incidence of affectations and, in general, the taxonomic group shows most of its elements in an acceptable state of conservation to be kept in the Exhibition Hall. An analysis of the anatomical structure of each of the specimens was carried out, which facilitated the prediction of their possible uses. Environmental education activities were also developed with the species evaluated through activities with circles of interest to reinforce their approach to preserved wood collections.

Keywords: *Mangroves, preserved wood collections, conservation.*

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BIODIVERSITY, ECOSYSTEM SERVICES AND ENVIRONMENTAL EDUCATION IN A FORESTED WATERSHED NEAR MEXICO CITY

Victor Avila-Akerberg*, Tanya Gonzalez-Martinez and Luis Angel Lopez-Mathamba

Mexico City has forested lands in the surrounding mountains that suffer an enormous anthropic pressure. For their conservation there is a need to assess and value these lands and the benefits they provide. In this study the main ecosystem services and biodiversity of a forested watershed with a high altitudinal gradient (2200-3870 m), west of Mexico City, are assessed. The Guadalupe dam watershed (GDW) contains a high population (ca. 1,5 million inhabitants), a unique natural beauty in the higher parts with many water bodies and crystal clear streams, vast and well-preserved vegetation cover and forests of oaks, firs and pines, together with some productive activities like potatoes and wheat agriculture, extensive livestock breeding, trout farming, silviculture and ecotourism. Biodiversity is fairly high, with an estimate of 1,500 species, mainly plants, animals and fungi, many of which are endemic. At medium altitudes semi-rural villages appear, with traditional maize croplands, intensive greenhouse agriculture and most of the population activities related to the tertiary sector: services and commerce. In the lowest areas of the region, it is mainly a densely populated urban area with circa 90% of the people living inside GDW in which contrasting living standards make different uses of the land. Currently the territory of GDW has an important social and economic backwardness, together with landscape degradation due to improper waste management and land use change. Based on this problem, our applied research intends to promote local development strategies from a better understanding of land use, biodiversity and ecosystem services provision and valuation, where environmental

education to kids and teenagers between 10 and 18 years is of primary importance. In the last 6 years, we have been able to promote participation and transfer information to more than 25,000 kids and teenagers, with positive results that will be presented.

Keywords: *Mexico City, Guadalupe dam watershed, environmental education.*

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PERCEPTION OF ENVIRONMENTAL QUALITY IN CITIES LOCATED IN BRAZILIAN ATLANTIC FOREST

Ana Alice Eleuterio* and Cynnamon Dobbs

Urban expansion, especially in biodiversity hotspot areas, is a major cause of biodiversity loss around the world. Urban planning for future cities should enhance resilience while accounting for environmental quality and human wellbeing. Also, should not disregard the importance of cities for the provision of ecosystem services, and biodiversity conservation. In this study, we aimed to evaluate how people from cities located in biodiversity hotspots of Atlantic Forest, Brazil, perceived the environmental quality in their municipalities. We used data from online questionnaires answered by 1188 citizens of 13 municipalities in the states of Sao Paulo, Parana, and Santa Catarina, Brazil. Questions assessed what participants thought about the quality, access, and management of water supplies, solid waste, green areas, air quality, food security, and participation, including access to information, knowledge about citizen's rights and governmental responsibilities. 54% of the people interviewed were members of civil society, and the remaining declared to represent a wide range of institutions. 93% of the people interviewed lived in urban areas, 51% were women, and 47% were man. Issues perceived as positive by most citizens interviewed included air quality, solid waste management, and presence (but not management) of public green areas. Although most participants recognized their role in biodiversity conservation in urban areas, preliminary results showed low involvement in issues related to environmental management. Environmental education programs, especially for building cities' resilience to climate change, were either perceived as absent or lacking information by most interviewees. Environmental programs that aim to enhance public participation in decision making should consider these results to build effective strategies. Further analysis will possibly identify groups with different perceptions, and contrast perceptions with real measures of environmental quality in the study area.

Keywords: *Online questionnaire, urban planning, participation, resilience, biodiversity hotspot.*

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COURSE SYLLABUS “THE IMPACT OF CLIMATE CHANGE ON FOREST”

Vitalie Gulca* and Jorje Alcazar

This research consisted in designing of basic, advanced and specialized syllabuses for the course “The impact of climate change on forest” in context of the International Project 543946 TEMPUS-1-2013-1-ES-TEMPUS-JPHES “Support for Vocational Training in Sustainable Forestry — SUSFOR” 2013–2016. To attain this objective we first describe some of the emerging international issues relating to the impact of climate change on forest. Then we assess the Lifelong learning (LLL) system in different regions of the world. Also, we analyze degree curriculums and syllabuses from faculties of environment and natural resources. Finally, we propose the basic

module “The impact of climate change on forest” to develop management practices to enhance forest carbon sequestration for the mitigation of climate change. The target group consists of land owners and everyone—from those who are in employment and seek self— fulfillment in learning to those in phases of ‘non-paid’ work, those who wish to use education to re-engineer their lives and their careers to people in their third age (to foster talent and more accommodating to weak learners); companies’ workers, anybody interested, forest owners, forest trainers, forest workers, vocational students.

Keywords: *Syllabus, climate change, Lifelong learning.*

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MINDSCAPES AND LANDSCAPES: FOREGROUNDING GHANA’S COMMUNITY RESOURCE MANAGEMENT AREA (CREMA) MECHANISM AS A SOCIAL LEARNING TOOL FOR FORESTED LANDSCAPE MANAGEMENT

Bob Manteaw*

In the face of increasing population growth, worsening poverty, lack of livelihood alternatives and perennial vulnerability most communities in Sub-Saharan Africa find livelihood respite in forests and associated ecosystems. Forest exploitation and degradation, especially in rural communities in most poor developing countries, are perceived largely as a matter of survival and a livelihood alternative. This situation is currently being exacerbated by the perniciousness of climate change impacts which is increasing vulnerability and degradation in forested landscapes and associated ecosystems. These have put tremendous pressures on forests as many human activities continue to be guided by narrow socio-economic rationalities that eventually cause deforestation and degradation. The challenge, therefore, in forested area management in many communities in Africa and in this case Ghana, has been how to strike a fair balance between human survivability and sustainable forest management. This paper foregrounds Ghana's Community Resource Management Area (CREMA) mechanism as an innovative natural resource governance and landscape-level planning tool that empowers communities at the local level to manage their natural resources sustainably for economic, cultural and livelihood benefits. The paper argues that CREMA as an innovative natural resource management tool offers a promising community-based structure and process for managing African forest resources. The paper further argues that while the CREMA concept continues to enjoy worldwide acknowledgement and praise as an effective management tool to enhance mitigation initiatives such as REDD+ and sustainability manage forests, the social learning imperatives of the concept has not been consciously explored and highlighted. Using Ghana as a reference, the paper makes the point that the effectiveness of CREMA as a management tool lies in its inherent social learning attributes. It is the paper’s argument; therefore, that CREMA as a learning tool has potential to transform ‘Mindscapes’ and ‘Landscapes.’

Keywords: *CREMA forest, community-Based, management, social learning, mindscapes, landscapes.*

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FARMERS' PERCEPTIONS ON PROPAGATION AND THE IMPACTS CLIMATE CHANGE ON GOODS AND SERVICES PROVIDED BY *GARCINIA KOLA* HECKEL IN SOUTHERN NIGERIA

O. P. Agwu*, A. Bakayoko and S. O. Jimoh

Garcinia kola is a multipurpose indigenous tree found in forests throughout West and Central Africa, it is an economically highly valued tree, used extensively in cultural and social ceremonies in the southern part of Nigeria. The study investigates the farmers' perceptions on propagation and the impacts climate change on goods and services provided by *G. kola* in southern Nigeria using a structured questioners and an interview section, the resulting data obtained was analysis using descriptive and inferential statistic such as frequency, percentage, Chi square and multinomial logit regressions. The results shows that farmers are not currently propagating *G. kola*, most of the available stance were inherited from grandparents. Most of the farmers still believe that its only good that can make *G. kola* to germinate, however, information about the new technology in raising *G. kola* was not spread across farmers communities. Over 93% of these farmers were not aware of this new technology. The fending also shows that farmers are well aware of climate change and its effects such as change in rainfall patterns, frequent drought and floods, increase in temperature and stronger winds. Chi square analysis shows no significant difference in farmers' perceptions about climate change between all the study area indicating that their knowledge might be similar. The results of multinomial logit regressions shows that age, sex, marital status, household size and education level are the main factors significantly influencing farmers' perception of climate change in study area. Finally, efforts should be made and initiate programme at educating the rural farmers' on propagation possibilities, potential ecosystem services and the impact of climate change on are multiple purpose agroforestry species such as *G. kola*.

Keywords: *Garcinia kola*, propagation, multiple purpose, climate change, agroforestry.

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THE CORE ROLE OF ENVIRONMENTAL EDUCATION IN BIODIVERSITY CONSERVATION

Diana Pungar*, Kalev Sepp and Maris Kivistik

Education has a core role in rising awareness of the quality and importance of Estonian landscape and forest conservation. In Estonia, different governmental and non-governmental institutions share the responsibility for landscape and forest education. The Ministry of the Environment has a leading part of environmental education, who cooperates with the Ministry of Education and Research.

The Ministry of Environment and the Education Department of the Environmental Board handles the field of environmental education and information, by improving sustainable development related study materials, offering free nature-related programs (indoor and outdoor) for students over Estonia and by increasing the environmental awareness of the population through projects, training courses, seminars and events. For example, courses for landowners, seminars in national parks, hiking tours in the protected areas and biodiversity and ecosystem services in the forest. Local children are involved in landscape conservation works in Estonian national parks by the project "Junior Ranger". Junior Ranger is a programme for teaching young people, who are interested in nature protection (initiated by EUROPARC Federation in 2002, in Estonia from 2004).

In the fields of landscape education, landscape conservation and forest education, much work is done by non-governmental organizations as Estonian Fund for Nature (EFN) and Estonian Seminatural Community Conservation Association (ESCCA). They arrange regularly events for nature conservation involving volunteer work and landscape education. Furthermore, recent surveys has shown positive effect on environmental awareness and rising knowledge about landscape conservation.

Environmental education brings nature closer to the community as well as teaches the values of ecosystem services. If local people are more familiar with their surrounding nature and landscape protection areas, they are more prone to understand the need and requirements for nature conservation.

Keywords: *Community involvement, awareness, forest education, caring.*

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ROLE OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN BIODIVERSITY CONSERVATION OF SATPUDA MOUNTAIN REGION OF MAHARASHTRA STATE - INDIA

Kalpana Chaudhari*

India is a predominately an agricultural country. More than 80% of its population lives in villages and about 70% of them depends on the agriculture and forestry .Agriculture and forestry contributes about 40% to the Gross Domestic product .Therefore any significant transformation of the national economy and people in mountain region cannot be conceived without the transformation of the agriculture and forestry sector. It is possible to achieve it through the application of science and technology as well as information and communication technologies for improvement of agriculture and forestry using biodiversity conservation in mountain region. Satpuda is a hilly/mountain region in the Maharashtra state located in central part of India which is now facing the problems of loss of biodiversity in past years either due to over use of natural resources or due to change in the environmental conditions. This paper deals with the role of different aspects of biodiversity conservation such as agricultural and forest species, social forestry etc. in recent years .it also discusses the causes of the loss of biodiversity in this region, its effect on the socio-economic condition of the region and the past effort to conserve the biodiversity so as to avoid the environmental impacts. The paper also discusses the role of the local people in conserving the biodiversity for their socio-economic development using information and communication technologies. It also emphasizes the need for extensive capacity building for assessment and conserving the biodiversity in the Satpuda mountain region using the public participation for maintaining the ecological and environmental balance in this region using ICTs.

Keywords: *Biodiversity, environmental education, ecological conservation, ecosystem, forest degradation.*

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Session 1.5

Major trends in forest degradation in Latin America: which way forward?

Chairs: Dolors Armenteras and Plinio Sist

WHAT LIES BENEATH: CONTIGUOUS FOREST COVER AND FOREST DEGRADATION IN THE PERUVIAN AMAZON

Cara Rockwell*, Manuel Guariguata, Angelica Almeyda Zambrano,
Eben Broadbent and Quaedvlieg Julia

The Department of Madre de Dios in Peru provides an ideal landscape in which to witness the impacts of anthropogenic disturbances on forest cover and structure. The local economy relies heavily on Brazil nut and timber, two important forest products that play critical roles in forest conservation and exploitation. Even so, few studies have demonstrated that timber and non-timber forest product (NTFP) extraction are compatible land use strategies. Indeed, even when adhering to the legal channels, forest managers harvest timber in an opportunistic fashion with multiple entries into the same harvest zone. Many valuable hardwood species are now extremely rare in Brazil nut concessions within close proximity to the Interoceanic Highway, even though Brazil nut concessions are characterized by contiguous forest cover. This trend calls into question the integration of timber into traditional land management objectives, especially since most timber is harvested illegally. We investigated the influence of timber harvesting on forest structure, woody species composition, available commercial volume, and commercial tree seedling abundance. Response variables were compared between three Brazil nut concessions (290-576 ha) using modified 0.5 ha Gentry plots. We discovered that logged sites were characterized by a lack of advanced regeneration, low commercial timber volume, and reduced commercial taxonomic composition. We also assessed forest value across the concessions, based on estimates of commercial timber and NTFP values as well as other environmental services, and evaluated the implications of forest degradation for the local economy and community members. Results from this study will underscore the need for future monitoring of harvesting activities and residual stand dynamics as well as extreme caution in engaging in opportunistic logging practices.

Keywords: *Tropical rainforest, Peru, Brazil nut, timber, sustainable forest management.*

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ENVIRONMENTAL ZONING PROPOSAL FOR THE MORRO GRANDE FOREST RESERVE, COTIA CITY, SÃO PAULO STATE, BRAZIL

Yuri Tavares Rocha* and Thiago Betim Flores

The conservation of forest fragments in urban areas, such as the São Paulo Metropolitan Region (SPMR), contributes to the maintenance of the environmental quality of urban landscapes. Among the most important contributions of environmental planning, is the zoning, which is contemplated in the Brazilian Environment National Policy. The zoning serves to reconcile the use and nature conservation through the potentialities and fragilities of the areas. The Cotia City, one of the 39 municipalities of the SPMR, preserves the Morro Grande Forest Reserve of (MGFR), 10,700 hectares of the Atlantic Forest reminiscent that suffers the negative environmental impacts of urban expansion in its environment. The objectives were: to analyze the physical components of the MGFR; delimit landscape units of the RFMG; and, develop a proposal for environmental zoning for the MGFR. An analysis of the secondary data on the MGFR was made and the cartographic elements were made: hypsometric map, elevation three-dimensional model map and map of geomorphological units. The existing land use and occupation map was combined with these thematic maps and a map of environmental fragility was elaborated according to Ross (1995), delimiting 11 landscape units, which were considered in the location of the environmental zones for the RFMG. The Federal Law 9.985/2000 was considered about the zones definitions. The proposed zoning established the division of MGFR into two large zones: Integral Protection and Sustainable Use, both were subdivided according to their characteristics, restrictions and use

criteria. This proposal for environmental zoning for the MGFR aimed to contribute to a better conservation of this important forest reminiscent of the SPMR and for the next revision of the MGFR management plan, to achieve a more responsible and more appropriate management with its landscape and protection of its natural resources.

Keywords: *Urban Forest, Environmental Zoning, Management Protected Area, Landscape units.*

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VEGETATION MONITORING IN THE RESERVE FOR NATIONAL PARK SAN RAFAEL PARAGUAY AND GENERAL GUIDELINES FOR ITS RESTORATION

Janet Villalba Marín*, Patricia Chena Insfrán, Raquel González Lesme,
Alejandra Gill Ojeda and Stella Mary Amarilla

The Atlantic Forest (BAAPA) has been identified as a priority for global and national conservation (Contraloría General de la República 2005) by many experts and initiatives. The San Rafael Reserve for National Park (RPNSR) is the second biggest remnant of the BAAPA in Paraguay (De Egea y Balbuena 2011), whose problematic is complex. The aims of this study were to characterize the forest degradation in the San Rafael Reserve for National Park and to propose general guidelines for its restoration. We applied the Normalized Differential Vegetation Index (NDVI), proposed by Rouse et al. (1974), and examined a time series of six years (2011 to 2017) in the cloud base geospatial platform Google Earth Engine (GEE), using images of Landsat 5 and 8, corresponding to scene 224/7. To propose the restoration general guidelines we took into account the results of the characterization of the forest degradation, literature recommendations and its applicability for the RPNSR. The results indicated that there are changes in the vegetation's behavior that decreases its photosynthetic activity through time. To aboard restoration projects it should be considered topics such as the complex of the problem, the degradation, social aspects, legality and others.

Keywords: *NDVI, Google Earth Engine, forest degradation, restoration.*

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EDGE INFLUENCE IN FOREST AND SAVANNA VEGETATION: EXAMPLES FROM THE BRAZILIAN CERRADO

Pavel Dodonov*, Fernando Andriolli, Milton C. Ribeiro,
Karen A. Harper and Dalva M. Silva-Matos

One of the factors through which habitat loss and fragmentation affect biodiversity is edge influence, which results in ecological changes next to the edge compared to interior areas. Non-forest vegetation has been little studied with regard to this process. We assessed edge influence on microclimate (air temperature and moisture), vegetation (plant litter, graminoids, and vegetation structure), and animals (dung beetle community and bird nest predation) in the Brazilian cerrado, including forest and savanna vegetation distributed among 23 fragments, with 1 to 15 fragments per study. Most of the variables were affected by edges in at least some fragments, usually up to 5-30 m from the edge. Temperature at edges tended to be higher and moisture tended to be lower. Plant litter at the edges differed from forest interior, with less twigs and more dead grass. In savannas there was marked edge influence on the ground layer, with an

increase in the cover of the African grass *Urochloa decumbens*, sometimes accompanied by a decrease in native grasses. In forest vegetation, canopy trees at the edge were often taller than in the interior. The abundance, but not richness, of dung beetles was affected by edges, with effects differing among the dung beetle guilds. Nest survival was greater in the interior for nests placed at a lower height m above ground and predation by birds was higher at the edge for nests placed at a greater height. Edge influence was generally not restricted to high-contrast edges and even narrow firebreak edges had significant effects, but there were some differences between eucalypt, sugarcane, and pasture edges. Edge influence is thus an important factor to be considered for management of vegetation remnants, and this importance is not restricted to forest vegetation, as savanna, and likely grassland areas as well, may be affected by edges.

Keywords: *Cerrado, edge effects, invasive grasses.*

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THE SPACES OF TERRITORIAL TENSION BETWEEN THE LA PRIMAVERA FOREST AND THE METROPOLITAN AREA OF GUADALAJARA

Israel Melo Coronado*

The urban-rural-forest frontier is the space of territorial tension where the different key actors of the urban system compete and adapt. In these border spaces, conditions of uncertainty and conflict are generated as a result of the overlap between different territories made up of private, ejido and state property.

In Mexico, the territorial limits at the state and municipal levels are confusing and undefined, consequently in these border areas there are spaces where no domain is claimed over it, or, on the contrary, there are historical territorial conflicts due to their possession.

In the particular case of the Protected Natural Area of the La Primavera Forest in Guadalajara, selective logging is not a representative cause of the degradation of the forest cover derived from the high concentrations of silicon oxide (SiO₂) in the soil; however, the Forest fires of anthropogenic origin are one of the main disturbances that influence the degradation of forests and evidence the growing need for urban land for agriculture and livestock, and housing. In addition, said process of degradation of the territory and the consequent institutional response for its protection are closely linked to periods of state political management.

In order to identify those areas of territorial tension in the La Primavera Forest, an analysis was carried out that links the priority areas for fire control against buffer overlaps between the legal limits of the protected natural area and the physical limits of the urban sprawl. Derived from the previous analysis, those border spaces that effectively coincide with representative events were identified in the territory, which could mean an area of opportunity in the management of natural reserves that has not been fully explored within local urban planning.

Keywords: *Territorial tension, La Primavera, border space.*

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IMPACTS OF DOMESTIC CATTLE ON FOREST AND WOODY ECOSYSTEMS IN SOUTHERN SOUTH AMERICA

Flavia Mazzini*, M. Andrea Relva and Lucio R Malizia

There is a long lasting debate on the effects of domestic cattle grazing on natural ecosystems worldwide. Cattle are generally assumed to have negative effects to forest conservation; however, several studies also report positive and neutral effects. We aimed to investigate the available evidence for positive, negative and neutral effects of cattle grazing on forest and woody ecosystems of southern South America. We conducted a peer-review literature search using the ISI Web of Knowledge and Scopus databases in order to identify studies dealing with cattle impacts for nature conservation. We compiled a database of 211 cases from 126 original publications. A reduced number of forest ecosystems (Patagonian forest, Chaco and Monte) concentrated ~85% of the reported study cases. The hierarchical cluster analysis to group cases based on cattle effects, ecological variables and ecosystems reported that negative effects (~66% of cases) were mostly informed for vegetation variables and mainly occur in Patagonian forest and Chaco; positive effects (~16%) were mostly informed for Monte (no particular variable associated), while neutral effects (~18%) were mostly informed for fauna related variables and Uruguayan savanna. Our study suggests that grazing effects by cattle on southern South America forests are not homogeneous and depend on the particular forest ecosystem considered as well as on the forest attribute measured. Different cattle effects found can be partially explained by differences in grazing history and different ecosystems productivity. It is vital to improve our understanding of cattle-forest interactions to guide synergies between sustainable management and forest conservation.

Keywords: *Bos taurus*, Domestic livestock effects, Forest structure composition and dynamics, Grazing, Native Forests.

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INSTITUTIONALIZING STATE PROPERTY FORESTS FOR MANAGEMENT OF FOREST FIRES AND RESTORATION OF ECOSYSTEM SERVICES IN HIMALAYA

Prakash C. Tiwari* and Bhagwati Joshi

In Himalaya, 85% forests are state property in which rural communities enjoyed traditional resource use rights and concessions; and in turn contributed significantly towards their conservation for thousands of years. However, after creation of network of protected areas community resource use activities have been prohibited in state forests alienating people and collapsing indigenous forest management system. Consequently, forest resources have depleted steadily and significantly due to weakening of traditional forest management institutions and climate change. Moreover, climate change has increased the susceptibility of the Himalayan forests to wildfires; and every year thousands of hectare of forest is ruined by fires. Increasing incidences of forest-fires have disrupted basic ecosystem services, contributed to climate change and destabilized indigenous adaptation mechanism. It is therefore highly imperative to involve local communities in the governance of state forests by linking forest conservation with rural livelihood improvement, poverty reduction and climate change adaptation through reviving strengthening traditional forest governance institutions.

Study aims to evolve an institutional governance framework for controlling forest-fires through participatory governance of state property forests with case illustration of Kumaon Himalaya. Methodology included comprehensive empirical study of recently revived Forest Panchayats (Village Forest Councils) in Uttarakhand Himalaya; and assessment of the scope of its extension to state property forests. It was observed that 95% Forest Panchayats are not only managing risks

of forest-fires; but also enhanced carbon sequestration capacity of forest ecosystem through increase in forest cover, improved traditional adaption practices in water, biodiversity and livelihood sectors. In view this; an institutional framework was evolved for participatory and adaptive governance of state property forests. It is expected that proposed institutionalization of state forests will go long way in mitigating the risks of forest fires and climate change across Himalayan mountains and enhancing community coping mechanism to

Keywords: *Traditional forest management institutions, climate change, poverty reduction, Village Forest Councils, adaptive governance.*

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EFFECTS OF FIRE ON THE COMMUNITY OF SMALL NON-FLYING MAMMALS IN LANDSCAPES UNDER FIRE INFLUENCE

Tania Marisol González* and Dolors Armenteras

The Colombian region of the Orinoco is an area considered a biodiversity hotspot, besides being an area that provides multiple ecosystem services. However, this is one of the most affected areas in the country by Climate Change and productive activities, which has facilitated several periods of severe droughts in this region. These features create a conducive environment to uncontrolled fires, increasing plant and animal mortality. Fire can act as disturbance driver for fauna communities, mainly affecting the vegetation structure and composition, but fire also impacts the ecology of species, populations and communities in the short, medium and long term. At the tropics, there is little evidence of how mammals use burned and unburned habitats, and how biodiversity attributes are affected by fire and its regimes. It is important to know how landscapes influenced by fire affect the dynamics and structure of non-flying small mammals' communities and their diversity, abundance, richness and microhabitat use. This project has collected information of non-flying mammals, vegetation and landscape configuration data, as well as fire. This information has been used to parameterize models of response of these animals to fire, affording a better understanding of the impact of fire disturbances on small non-flying mammals community. Currently, the influence of landscape configuration resulting from fires on the diversity of small non-flying mammals is under evaluation. The project is contributing and supporting the development of the tropical fire ecology in Colombia, a research field that has been underdeveloped in the country despite the great impact this natural or man-made disturbance has on the ecosystems. This type of study is important because it will permit the development of landscape scale management strategies, thus helping to mitigate the effects of change in land use and ensure the sustainable development of the Orinoco region in Colombia.

Keywords: *Colombia, small non-flying mammals, wild fires, fire ecology, forest management.*

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LARGE SCALE MONITORING OF FOREST DISTURBANCES IN THE BRAZILIAN AMAZON WITH THE $\Delta rNBR$ INDEX

René Beuchle*, Yosio Shimabukuro, Egidio Arai, Luiz Aragão and Andreas Langner

Disturbances of forest due to selective logging and forest fires are a common issue in many parts of the tropical belt, having an important impact in the context of forest biomass and biodiversity. In consequence, the assessment of forest degradation is a key component of international policies

such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation). While the techniques for the monitoring of tropical deforestation with remote sensing imagery has made fast progress in recent years, the mapping of forest disturbances over large areas remains a challenging topic, due to the often rapid disappearance of the signs of logging infrastructure or the burned forest areas through re-greening or grow-back of vegetation. We propose a new, semi-automatic, cloud computing – based annual mapping of disturbed forest with an adapted Normalized Burn Ratio index rNBR, which is applied as yearly change detection approach on Landsat 8 imagery for the dry season (July to November) of the years 2014, 2015 and 2016 over Northern Mato Grosso, Brazil, with an area of interest covering more than 200.000 km² of tropical rain forest. The disturbance severity, related to selective logging and forest fires, and the changes over time were assessed by the integration of the pixel-based $\Delta rNBR$ on fixed grid cells of 300 m X 300m. From 2014 to 2015 the area affected by selective logging and forest fires almost doubled from 642 km² to 1202 km² and 221 km² to 372 km² respectively, while both values showed a decrease in 2016 to 815 km² and 360 km², correspondingly. The percentage of the highest disturbance severity class over the three years ranged from 8 – 13% for selective logging and 20 – 26% for forest fire, both having the highest share in 2015.

Keywords: *Forest degradation, remote sensing, Amazon, REDD+, carbon emissions.*

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MULTI-SCALE SPATIAL PLANNING IN DEFORESTATION FRONTIERS OF THE ARGENTINE CHACO: OPPORTUNITIES TO REDUCE FOREST FRAGMENTATION AND CONNECTIVITY LOSS

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Gregorio Gavier-Pizarro and Tobias Kuemmerle

Forest loss and fragmentation are major threats to biodiversity and ecosystem service provisioning. The South American Chaco is a global deforestation hotspot, due to agriculture expansion. In the Argentine Chaco, deforestation is zoned by the Forest Law, implemented at the provincial level. Yet, whether the current zonation is effective in avoiding unwanted environmental outcomes remains unclear. The province of Formosa faces deforestation rates of 23,000 ha year⁻¹, and future deforestation is likely to be widespread. Formosa is the only province in Argentina that designates a set of corridors to maintain forest connectivity. We simulated potential future forest cover for different spatial planning scenarios to assess the effect on forest spatial configuration of (a) implementing current regional corridors and (b) enacting additional policies to minimize forest fragmentation at the plot level. We developed both options under high and low deforestation rates. We then quantified forest connectivity and fragmentation using structural landscape indices. Our results show that implementing regional corridors reduced the extent of potential deforestation by 650,000 ha (43%) and this alone strongly increased forest connectivity compared to scenarios without corridors. However, the patterns of deforestation at the plot level were critically important. Plot-level spatial planning could have a strong and positive effects on mitigating fragmentation and maintaining connectivity, even in scenarios with high deforestation rates (i.e., reduction of the number of forest fragments by up to 35%, increase in core forest by up to 6%). Moreover, under high deforestation rates, implementing regional corridors and plot-level spatial planning had a strong complementary effect on mitigating forest

fragmentation (17% less forest fragments than when implementing either of the two strategies alone). Our analyses highlight the opportunities of complement regional-level zoning with plot-level landscape design, in order to reduce the negative outcomes of deforestation, in the Chaco and other active agricultural frontiers.

Keywords: *Corridors; Forest Law; landscape planning.*

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FOSTERING KNOWLEDGE SHARING ABOUT AFROFORESTRY SYSTEMS THROUGH THE CODESIGN OF A ROLE-PLAYING GAME WITH FARMERS AND STUDENTS FROM THE MUNICIPE OF IRITUIA (NORTHEAST PARA, BRASIL)

Christophe Le Page*, Eva Perrier, Layse Braga,
Lívia Alves Navegantes and Emilie Coudel

The companion modelling approach aims at stimulating social learning among stakeholders through the interactive use of agent-based simulation models. In the Municipality of Irituia (Northeast Para, Brazil), such a process was initiated to enhance knowledge sharing among farmers, researchers and students about environmental restoration in relation to agroforestry systems. A first version of a stylized yet empirically grounded model of 4 similar 25-ha family farms was first designed by a group of researchers. This tool, oversimplified, served as a sketch to initiate the co-design process. We present here the iterative steps of progressive shaping and improvement that were needed for the tool to become usable with people who were not involved in its design. Handled as a role-playing game (the actions of the farmers are decided by the participants), the tool was first introduced to a group of farmers who were selected because of the experience in agroforestry systems. Eliciting their knowledge and formalizing their practices allowed us to propose archetypes of agro-forestry systems. The game was first tested by students from Itabocal, a rural school of Irituia Municipality. In the game, when deciding to start agro-forestry, a participant has to select a type of pre-defined agro-forestry system. The growth of the plants is simulated by the computer model and a set of indicators is provided to the players for them to assess the balance between environmental and socioeconomic benefits. The model was fine-tuned through a series of successive workshops. We present how it enabled fostering knowledge sharing among students, farmers and researchers.

Keywords: *Companion modeling, Amazon, restoration, family farmers.*

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AGROFORESTRY AS A STRATEGY FOR FOREST RESTORATION: LEARNING FROM EXPERIENCES CARRIED OUT BY FAMILY FARMERS IN EASTERN AMAZON

Emilie Coudel*, Lívia Navegantes Alves, Joice Ferreira,
Renan Carneiro and Rosileia Carvalho

In Brazil, the forest legislation has opened up new options for forest restoration by smallholders, allowing in particular the use of agroforestry in conservation areas. This has triggered a vigorous national debate, involving social movements, scientists and policy makers: while these legislative

changes may encourage farmers to engage in restoration, the provision of environmental services greatly varies according to the type of agroforestry system. At the same time, the models proposed by NGOs and scientists often overlook the traditional knowledge that farmers have developed in agroforestry systems. Moreover, few studies have assessed the balance between environmental and social benefits of the different systems.

To contribute to this debate, we analyzed agroforestry systems implemented by farmers in the Northeast of the state of Pará, around Belem, a region colonized almost a century ago and where there is a great diversity of agroforestry systems. By combining interviews with key actors, 120 questionnaires with farmers and in-depth analyses of different production systems, we elaborated a typology of the different agroforestry systems, to assess their potential for environmental restoration. Although environmental restoration is rarely the prime objective, in many cases, the farmers have consciously tried to restore environmental functions and consider that production has improved following the diversification of the system. Moreover, the environmental restoration can involve more than the agroforestry plot, as the farmers can let surrounding forest regrowth regenerate. The knowledge developed by the farmers, including the combination of species and the integration of the agroforestry within the production system, must be better valued and contemplated by the institutions which support restoration programs.

Keywords: *Amazonia, family farmers, restoration, agroforestry.*

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ENVIRONMENTAL AND SOCIO-ECONOMIC ROLES OF NATURAL TROPICAL FORESTS IN RESTORATION SCHEMES

Plinio Sist* and Marie-Ange Ngobieng

The Bonn challenge launched in 2011 has created new interest in forest landscape restoration. Within the initiative 20x20 in Latin American countries committed to restore 20 millions ha by 2020. Forest restoration actions are obviously not limited to planting trees; they must be implemented at landscape level taking into account the different land-use systems as well as the different stakeholders. In the degraded landscapes of the Brazilian Amazon, most of the forests have suffered different degrees of uses from selective logging to repeated logging and fire. Abandoned lands are colonized by regrowth forests of different age and with different history of past disturbance. All these so called degraded forests are usually considered of low interest by both population and decision makers. In this presentation, we will present our present knowledge on forest degradation characterization and will demonstrate the crucial importance of these ecosystems in restoration actions.

Keywords: *Amazon, degraded forests, forest restoration.*

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FOREST RESTORATION IN THE HUMID TROPICS: LESSONS DRAWN FROM A SYSTEMATIC MAP

Lilian Blanc*, Ophélie Ratel, Eric Nicolini, Emilie Coudel and Plinio Sist

The critical need for forest restoration is widely recognized especially in the tropical regions. Forest restoration is a major option to reduce the vulnerability of the forest cover, to increase biodiversity resilience and to provide additional ecosystem services. Regional initiatives of forest restoration were recently launched to increase forest cover in the Asia-Pacific region (APEC 2020 Forest Cover Goal), in Latin America (Initiative 20x20) or in Africa (AFR 100). To reach these commitments, scientific community is asked to produce knowledge and references to guide restoration initiatives. Forest restoration experiences were launched in the past three decades mainly in the South-East Asia region. Various restoration models were implemented (from monoculture plantation to natural regeneration) for different objectives and in several socio-economical context. We produced a synthesis to draw the main lessons based on a literature review of published papers. Our objective was to identify gaps, biases and trends on forest restoration in the humid tropics. We focused on two main questions. What models of forest restoration models were studied? Did the studies analyse the socio-economic context as well as the ecological context? It is known that a good understanding of the social-ecological context associated is a key factor for successful restoration. Our literature review followed the guidelines of evidence systematic methods. We followed the process-based methodology for systematic mapping aiming at collating, describing and cataloging available evidence relating to our research questions. The research was conducted on three databases (CAB Abstract, Web of Science & Scopus). A total of 388 papers were identified through the selection processes. We produced a systematic map that shows that very few papers analysed socioeconomic attributes of restoration experiments. Agroforestry and monoculture plantations were the most dominant restoration models studied in the three tropical regions. However in the last decade, a clear focus was given in the natural regeneration.

Keywords: *Forest restoration, systematic map, restoration models, humid tropics.*

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LANDSCAPE ECOHYDROLOGY FOR PEOPLE: PATTERNS, ECOSYSTEM SERVICES, AND THE ROLE OF THE COMMUNITY IN BOLIVIAN SUB-ANDEAN REGION

Fabio Salbitano*, Giulio Castelli, Tommaso Pacetti, Yandery Kempff
and Arturo Sanchez-Azofeifa

The relationships between landscapes spatial patterns and ecological processes, affects and is affected by the heterogeneity of ecological and social processes occurring across a range of spatio-temporal scales. At the watershed scale, landscape pattern and dynamics influence the attributes of ecohydrological process that can be converted to ecosystem services available for the society but dependent on governance and implementation actions. Thus, the spatial explicit evaluation of coupling eco-hydrological processes and WES provision, namely Landscape Ecohydrology, can highlight the existing relationships between social issues (e.g. land use, land tenure, evidence based local knowledge, openness and willingness to change) and the landscape ecohydrological functioning. The aim of the contribution is to assess the potential of a Landscape Ecohydrology

framework for the analysis of the degraded watershed of Rio Pirai, in the sub-Andean region of Santa Cruz de la Sierra, Bolivia. The watershed is the main source of wide range of ecosystem services for Santa Cruz (food, water provision and regulation, biodiversity, landslide and flood mitigation) and of the rural communities living both in peri-urban settings as well as in remote zones of the area. The main evidence is that the watershed area has been affected by severe anthropogenic changes in the last 50 years, finally carrying to a generalized land degradation. Historical land use maps based on the time series of Landsat Imagery have been assessed through landscape metrics. SWAT (Soil and Water Assessment Tool), then used for the spatially explicit modelling of hydrological processes and ecosystem services provision. Landscape metrics have then been associated with ecosystem services value, evaluating the shifts of the WES hotspots. The land use changes are discussed through a qualitative evaluation of societal determinants so to understand the main drivers of change and to identify nature-based solutions that could be introduced to initiate a protection/restoration process.

Keywords: *Landscape ecohydrology, climate change, ecosystem services, nature-based solutions, community engagement.*

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CHANGES IN FOREST COVER REGULATE STREAMFLOW IN CENTRAL NIGERIAN GALLERY FORESTS

Rahila Yilangai*, Sonali Saha, Amartya Saha and Augustine Ezealor

Gallery forests in sub Saharan Africa are drastically disappearing due to intensive anthropogenic activities thus reducing ecosystem services, one of which is water provisioning. The role played by forest cover in regulating streamflow and water yield is not well understood, especially in West Africa. This pioneering 2-year study, investigated the interrelationships between plant cover and hydrology in protected and unprotected gallery forests. Rainfall, streamflow and evapotranspiration (ET) measurements/estimates over 2015-2016 were obtained to form a water balance for both catchments. In addition, transpiration in the protected gallery forest with high vegetation cover was calculated from stomatal conductance readings of selected species chosen from plot level data of plant diversity and abundance. Results showed that annual streamflow was significantly higher in the unprotected site than the protected site, even when normalized by catchment area. However, streamflow commenced earlier and lasted longer in the protected site than the degraded unprotected site, suggesting regulation by the greater tree density in the protected site. Streamflow correlated strongly with rainfall with the highest peak in August. As expected, transpiration measurements were less than potential evapotranspiration estimates, while rainfall exceeded ET in the water cycle. The water balance partitioning suggests that the lower vegetation cover in the unprotected catchment leads to larger runoff in the rainy season and less infiltration, thereby leading to streams drying up earlier, than in the protected catchment.

This baseline information is important in understanding the contribution of plants in water cycle regulation, for modelling integrative water management in applied research and natural resource management in sustaining water resources with changing land cover and climate uncertainties in this data poor region.

Keywords: *Evapotranspiration, gallery forest, rainfall, streamflow, transpiration.*

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Session 1.6

Management of native forest
and forestry landscapes
for biodiversity conservation

Chairs: Gregorio Gavier-Pizarro, Natalia Fracassi
and Jaime Bernardos

MANAGEMENT OF MINIMUM IMPACT FOR DIVERSITY CONSERVATION IN NATIVE LOWLAND FORESTS OF MARAJÓ ISLAND, STATE OF PARÁ, BRAZIL

Michelliny Pinheiro de Matos Bentes*, José Antônio Leite de Queiroz,
Raimundo Nonato Guimarães Teixeira, Ruy Rangel Galeão,
Victória Cristina Oliveira de Souza and Taissa Higino

In the riparian communities of the Marajó Island in the State of Pará, North of Brazil, the traditional management of native lowland forests by the selective exploitation of commercial wood and non-timber forest products (NTFPs) has been being a long-term economic opportunity for the local inhabitants. The heart palm (*Euterpe oleracea* Mart.), a native species from these areas, is the source of an important nutritional meal in the livelihoods of the rural areas and a main product of the agricultural sector in the State of Pará, including national and international markets. Though, the traditional exploitation of heart palm trees presents a series of peculiarities revealed into threat indicators for biodiversity conservation in these forest landscapes. The objective of this study was to evaluate the behavior of a lowland forest structure and diversity after applying the management of minimum impact - MMI of heart palm trees by the inhabitants of the Mapuá Extractivist Reserve, in Marajó Island. The MMI is a decision tool for cutting the exceeding heart palm and other native tree species that affect heart palm fruits productivity. It favors light incidence by keeping a satisfactory and diverse number of native tree species in the area, especially the polinization fauna. Under the aspects of changing the management process practiced by the community, after almost three years main results reveal a positive change due to the increase of potential vigorous heart palm trees in the area and future income, beyond food security and the keep of multiple use tree species in the forest landscape. The experience, however, can be enhanced and improved through public policies to strength the activity.

Keywords: *Heart palm, lowland forest, multiple use species, tree diversity, food security.*

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HEMEROBY AND ENVIRONMENTAL ZONING OF THE IPIRANGA RIVER SPRINGS STATE PARK, SÃO PAULO CITY, SÃO PAULO STATE, BRAZIL

Yuri Tavares Rocha* and Mariana Silva Fernandes

In the urban landscapes, it's essential to consider the transformations caused by anthropic actions. Jalas (1953) proposed the Hemeroby index to classify the degree of alteration of the landscapes, from the extreme naturalness to the extreme anthropization. Sukopp (1972) defined the Hemeroby as the totality of the human beings effects, voluntary or not, in the landscape. The Ipiranga River Springs State Park (ISSP) is a protected area (476 hectares) located in the São Paulo City Southern and one of the important relicts of the Atlantic Forest of the São Paulo Metropolitan Region. The Hemeroby concept used in this research classified the landscape units (LUs) according to the degree of the alteration of nature caused by anthropic action; and, compared such UPs with the zoning of the ISSP Management Plan (2007). For that, the same material used for the elaboration of this Plan was used: geology; geomorphology; hydrology; vegetation; buildings, infrastructure and equipment; public policies and legislation; property situation; points of impact or vulnerability; recognition activities; and, land use and occupation. In addition to this material, photointerpretation of the ISSP was used by means of orthophotos with a resolution of 45 cm. The vectorization of the LUs was developed with the ArcGIS 10.2. Seven UPs were found with a minimum, very low, low, medium, high, very high and maximum degree of Hemeroby. The proposal of the new environmental zoning of the ISSP, based in Hemeroby Index, tried to identify the effects that the human appropriation caused in the natural landscape; and, collaborated for the immediate identification of management areas, especially those that have intensive use of their

resources, which can contribute to a better management of the ISSP, which is a refuge for various species of fauna and flora of this Urban Atlantic Forest.

Keywords: *Hemeroby, urban forest, environmental zoning, management protected area.*

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STARK INCREASE IN POTENTIAL SINK HABITAT FOR GIANT ANTEATERS IN THE ARGENTINE CHACO DUE TO LAND-USE CHANGE

Asunción Semper-Pascual, Julieta Decarre*, Matthias Baumann, Yamil Di Blanco, Micaela Camino, Bibiana Gómez-Valencia and Tobias Kuemmerle

Land-use change threatens biodiversity globally, and understanding where and how land-use impacts species of conservation concern is therefore important. Local extinctions are preceded by population declines, and these declines can extend beyond the actual footprint of land use. Assessing the geography of abundance changes in relation to land-use change allows the development of effective strategies to avoid population losses, but this is rarely done. We developed and mapped indicators of population change for the threatened giant anteater (*Myrmecophaga tridactyla*) in the Argentine Dry Chaco, a global deforestation hotspot. Specifically, we used an occupancy framework and extensive camera-trap data to proxy abundance changes between 1985 and 2013. To do so, we fitted single-season occupancy models for 2013, and then tracked occupancy back in time by projecting our models to land-use maps from 1985 and 2000. As land-use variables were the only time-variant predictors in our models, we were able to assess both the direct and indirect effect of land use on occupancy. Our results show that anteater occupancy decreased substantially since 1985, especially after 2000 when rapid agricultural expansion occurred (i.e., up to ~76% between 1985 and 2013). The area in which occupancy declined was much larger than the area affected by land-use change itself (e.g., ~160,000 km² of Ψ decrease vs. ~65,000 km² of forest loss) and declines extended far into seemingly untransformed habitat. The widespread areas of potential sink habitat we found highlight the urgent need for conservation planning and action to ensure a future for the anteater in the Argentine Chaco. More broadly, our study exemplifies how species may lose much of their high-quality habitat through direct and indirect effects of land-use change, and where pro-active (e.g., protecting remaining source habitat) and re-active (e.g., restoring sink habitat) conservation strategies could be spatially targeted to halt local extinctions.

Keywords: *Agricultural expansion, deforestation, Gran Chaco, occupancy modeling, anteater.*

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RELATIVE IMPORTANCE OF LOCAL HABITAT CONDITION AND LANDSCAPE FACTORS FOR ANURAN CONSERVATION IN FORESTED AGRICULTURAL AREAS OF ENTRE RIOS, ARGENTINA

Romina Paula Suarez*, Gregorio Gavier-Pizarro and Laura Solari

Agricultural expansion and intensification lead to changes in the condition of natural environments and surrounding landscapes that affect biodiversity conservation in agroecosystems. There is debate on the relative importance of local and landscape factors that determine distribution of species and communities at site level. The objective of this study was to compare the response of anuran communities and focal species to local condition of aquatic

environments used as breeding habitat and surrounding forested agricultural landscapes structure at different spatial scales in Entre Rios, Argentina. We performed anuran calling surveys in at least three occasions between September 2012 and March 2013 in independent and randomly distributed headwater streams. We evaluated the response of richness and presence of focal species with different life-history traits to physical-chemical, morphometry, and aquatic and terrestrial riparian vegetation as local variables, and to composition and configuration landscapes variables quantified by Fragstat and QGIS tools within 250, 500 and 1000-m radius buffer areas using a priori GLM models. Richness and all focal species responded to both local and landscape factors. Richness decreases at sites with lower slope and depth while increases at higher aquatic vegetation cover and heterogeneity, total cover of forests within 250m and forest patches clumping within 1000m, being landscape variables more relevant than habitat local ones. Most focal species responses determined richness response, however we found different relevance of habitat and landscape variables as well as spatial scale associations at individual species level. Our results show the importance of considering both local and landscape factors for future prediction of agricultural expansion and intensification regional effects on these organisms, and allow us to suggest management practices to enhance anuran conservation in agroecosystems.

Keywords: *Anuran-conservation, agroecosystems, habitat-condition, landscape, spatial-scales.*

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CONSERVATION OF UNDERSTORY FERNS IN *ARAUCARIA ANGUSTIFOLIA* PLANTATIONS COMPARED WITH NATIVE FORESTS IN NORTHEASTERN MISIONES, ARGENTINA

Magalí Pérez Flores*, Agustina Yañez, Gonzalo Márquez,
Juan Manuel Cellini and María Vanessa Lencinas

Worldwide subtropical forests have been intensively transformed, with high impacts on biodiversity. However, among transformed lands, forest plantations could hold threatened biodiversity depending on their structural and management characteristics. The aim of this study was to assess the effect of *Araucaria* plantations over native forest's understory ferns in northeastern Misiones, Argentina. Fifteen plantations and adjacent native forests were surveyed (30 plots). Species cover was sampled by point intercept method in five 9 m-length transects per plot and forest structure was characterized in plantations. *Araucaria* density-AD, total density-TD, *Araucaria* basal area-ABA, and total basal area-TBA were analyzed in three categories: AD1= ≤ 150 ind.ha-1, AD2= $\Rightarrow 150 \leq 200$ ind.ha-1 and AD3= $\Rightarrow 200$ ind.ha-1; TD1= ≤ 400 ind.ha-1, TD2= $\Rightarrow 400 \leq 500$ ind.ha-1 and TD3= $\Rightarrow 500$ ind.ha-1; ABA1= ≤ 25 m².ha-1, ABA2= $\Rightarrow 25 \leq 35$ m².ha-1 and ABA3= $\Rightarrow 35$ m².ha-1; TBA1= ≤ 35 m².ha-1, TBA2= $\Rightarrow 35 \leq 45$ m².ha-1 and TBA3= $\Rightarrow 45$ m².ha-1. Canopy cover was also registered by hemispherical photographs (CC1 $\leq 85\%$; CC2 $> 85\%$). Regarding management, plantations were differentiated by time since last thinning (T1 ≤ 10 years; R2 > 10 years). Species cover was compared between sectors (plantations vs. native forests), and among categories of forest structure, canopy cover and management in plantations, by one-way ANOVAs.

Twenty-six fern species were found, being *Ctenitis submarginalis* (67%) the most frequent. Plantations (4) and native forests (8) presented exclusive species. Ferns cover significantly differed between sectors, with higher values in plantations than in native forest for *Alsophila setosa*, *Ctenitis submarginalis*, *Dennstaedtia globulifera* and *Didymochlaena truncatula*. Significant differences also were found according to forest structure, canopy cover and management. *Pteris deflexa* showed higher cover in CC2 and T1 than in CC1 and T2 respectively.

Dennstaedtia globulifera presented higher cover in lower categories of AD and TBA, and the same trend with ABA. *Megalastrum connexum* higher covers were associated to AD2. Forest plantations could be managed to benefit the development and conservation of ferns in northeastern Misiones.

Keywords: *Atlantic forest, forest management, biodiversity conservation, Paraná pine.*

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WIND EFFECT ON TREES IN RIPARIAN AREAS IN FORESTED LANDSCAPES

Oscar Bustos-Letelier*, Walter Bussenius and Carol Mena

The natural fall of trees in riparian areas due to effect of wind is an important source of coarse woody debris for mountain streams, improving fish habitat, influencing stream morphology, as well as a factor of change on the forested landscapes. This research presents a physical and probabilistic model to estimate the probability of a tree falling into the stream including the effects of tree lean and wind direction. A physical model was developed for calculating the critical wind speed required to overturn a tree. This critical wind speed is a function of maximum resisting moment of the tree root structure, crown cross sectional area, initial tree lean and the angle formed between wind direction and lean direction on the horizontal plane. A probabilistic model was developed for determining the probability that a tree could fall and reach the stream. This probability is a function of exceedance probability for a particular period of time, wind direction probability, tree location and tree height. The measurement of 120 native trees in two stands in the Maule's Coast Range along two creeks located in "El Picazo" Forest found that tree lean varied from 1 to 40 percent uphill and 1 to 25 percent downhill on slopes of 1 to 78 percent. Approximately 80 percent of the trees leaned downhill and 18 percent of the trees leaned uphill. Besides, it was possible determined the trees falling into the stream and those that could be management productively.

Keywords: *Wind impacts, disturbance landscapes, coarse woody debris.*

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SILVICULTURE OOF MIXED STANDS: DOES NATIVE TREES NATURAL REGENERATION CONVERT A MONOSPECIFIC PLANTATION INTO A MIXED STAND?

Juan Goya*, Micaela Medina, Sabrina Rodriguez and Marcelo Arturi

Forest plantations in Argentina are mainly established for commercial purposes although, under specific management conditions, they can yield diverse ecosystem services. The silviculture for mixed stands focuses on diverse commercial products as well as on increasing resources use efficiency, biodiversity and ecosystem services. Natural regeneration of native trees in commercial plantations, as well as successful native trees underplanting, proved that monospecific plantations can be converted into mixed stands. *Araucaria* plantations in Misiones, Argentina, 30-65 years old, and different stand structure, give opportunities for understanding the interaction between management and ecological processes over time. Partial results showed temporal trends in native trees spontaneous regeneration in such system which are promising in terms of increasing plant diversity in *Araucaria* plantations since they generated suitable

conditions for native trees establishment, survival and growth. About 80 native trees, and more than 60 trees per hectare (>10 cm dbh) of 20 valuable wood species, were found in mature araucaria stands, which can be managed for commercial production. As an example, 150 trees per hectare of *Cedrela fissilis* 15-43 years old were found in 67 years old araucaria stands. *C. fissilis* established after plantation reaching an uneven aged population of valued wood. Such results highlights the commercial potential of native trees regeneration, which makes it feasible and profitable the management of ecologically diverse plantations.

Keywords: *Mixed forest, plantations, ecosystem services, native trees.*

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HOW TO BLOOM THE GREEN DESERT: TIMBER PLANTATIONS AND NATIVE FORESTS IN THE NORTHWESTERN URUGUAY BEYOND BLACK AND WHITE PERSPECTIVES

Paola Pozo* and Ina Säumel

The ongoing debate on bone or bane of monocultural timber plantations demonstrates the need to develop alternative approaches that achieve productivity while conserving biodiversity as a global challenge in forestry. Within the Campos ecoregion in southeastern South America, grasslands cover about 70% of the Uruguayan territory and constitute a heavily used socio-ecological system subject to expanding land use changes by grassland intensifications, afforestation and soybean plantation for the globalized market. With the aim to review strategies for a functional integration of timber plantation into a grassland dominated region, we assessed forest community characteristics and stand parameters within one hectare permanent plots of nine native forests and nine *Eucalyptus* plantations in northwestern Uruguay. Species composition reveals significant distinctive community groups which are shaped by regeneration density, native and exotic richness, species and structural diversity. Native forests have a great similarity in species composition, including occurrence of invasive species, they harbor many species that are absent or rare in forest plantations and therefore play a decisive role in maintaining biodiversity. Although, regeneration density was significantly lower in plantations than in native forests, *Eucalyptus* plantations also harbor native species in the understory and demonstrate the possibility to develop strategies such as mixed species that will reduce negative afforestation impacts. Strategies to enhance regeneration processes of native tree species within plantations, to diversify horizontal structure and species composition such as the implementation of mixed buffer strips at the edge of plantations will foster integration of plantations into the local setting and are promising steps towards multifunctional, sustainable productive and biodiverse friendly landscapes.

Keywords: *Eucalyptus, gallery forest, grassland afforestation, multifunctional landscapes, park forest.*

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IDENTIFYING CONNECTIVITY CORRIDORS FOR MARSH DEER IN A LANDSCAPE DOMINATED BY AFFORESTATIONS IN THE DELTA OF THE PARANÁ RIVER, ARGENTINA

Natalia Gabriela Fracassi*, Javier Adolfo Pereira and Santiago Saura Martinez Toda

The delta of the Paraná River is one of the most important wetlands of South America. The final portion of this system, or lower delta, represents both the southernmost stronghold for the marsh deer (*Blastocerus dichotomus*) and the most extended area of commercial plantations with Salicaceae (*Populus* spp. and *Salix* spp.) in Argentina. To improve field conditions for developing plantations, infrastructure such as polders or water management (e.g., drainage of freshwater marshes) are carried out to impede the entry of water into plantation areas, affecting marsh deer habitat. As a result, the regional metapopulation of this ungulate comprises three poorly-connected subpopulations, inhabiting large tracts of plantations with non-intensive management or well preserved patches of the original vegetation. To obtain quantitative data for guiding conservation planning aimed at improving landscape connectivity for deer, we collected presence points of the species in the lower delta (n = 91) through camera-trap survey and interviews to local producers. We developed a regional connectivity network for deer by combining a habitat suitability model with factorial least-cost path density analysis. Our results showed at least three specific areas (i.e., least-cost paths) in the lower delta where efforts to increase habitat connectivity among subpopulations should be prioritized

Keywords: *Marsh deer, landscape, connectivity, afforestation, Delta del Paraná.*

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EVERGREEN FOREST REHABILITATION IN PUMILLAHUE, CHILE, THROUGH SUPPLEMENTARY PLANTING OF NATIVE TIMBER SPECIES

Roberto Ipinza*, Braulio Gutierrez, Jorge Gonzalez, Maria Paz Molina and Patricio Rojas

The harvested areas of evergreen forest are profusely and quickly invaded by *Chusquea quila*, inhibiting the development of regeneration and forest dynamics. The size of the resulting “quilantal” varies from a half to several hectares. There are approximately 500,000 ha of forests invaded by “quilantales”, which due to their economic importance for their owners, deserve their rehabilitation by planting valuable native timber species, in an arrangement that leads to recover biodiversity, minimize inbreeding and bring the forest closer to pre-alteration reference ecosystem.

According to a botanical inventory and the interest of the owner, in the Pumillahue farm, roble, ulmo, tepa, lingue and olivillo were selected as timber species, and rauli was selected as filling specie; all of them were classified in pioneer or final according to their ecology. In order to collect seeds that minimize inbreeding and guarantee local adaptation, seed routes were established at a distance of 40 to 50 m between trees of the same species; under those trees were installed meshes to collect seeds. The seeds were nursed maintaining the identification of each mother to later evaluate their performance according to their family structure.

After that, a trial was planted in random plot design, in three blocks, where each “quilantal” corresponded to a block. Six treatments of 3x2 factorial structure were tested; three levels of spacing (3x5, 3x3 and 3x2 m) and two proportions between pioneer / final species (50/50 and 67/33), in biodiversity row.

Survival and height were evaluated with ASREML software in two measurements; the first one immediately after planting in winter; and the second one after a full season of vegetative growth. The survival was close to 100% and the pioneer species ulmo and roble, showed the greatest increases in height. The heritability in this stage of growth is also high and significant.

Keywords: *Evergreen forest, rehabilitation, inbreeding, heritability, biodiversity row.*

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STUDIES ON GERMINATION OF BAN OAK (*QUERCUS LEUCOTRICHOPHORA* A. CAMUS)

Anuradha Thakur*

Quercus leucotrichophora A. Camus is an important component of western and central Himalayan vegetation. Unfortunately, it has become one of the most over-exploited tree species of Himalayas. The primary reason for over exploitation of *Q. leucotrichophora* is the high demand for green fodder in dry season and lopping of large branches for firewood. The effects of browsing, competition and shade on the establishment of seedlings can adversely affect the success of germination by reducing tree growth and influencing the proportion of species regenerating.

Investigation entitled “Studies on Germination of Ban oak (*Quercus leucotrichophora* A. Camus) was carried out in Himachal Pradesh, India during the year 2012-13 under nursery conditions with the aim to assess the rate of seed germination with different combinations.

The individual effect of seed size, seed color and sowing depth was found with the maximum values for germination per cent in large sized (43.89%), dark brown color seeds (39.44%) when sown at depth 1cm (47.04%), whereas for germination capacity the maximum value was obtained in large sized (59.44%), dark brown color seeds (53.33%) when sown at depth 1cm (67.04%). Similar trend was observed in other germination parameters. It was found that effect of interaction for large size (S1) dark brown color seeds (C2) sown 1cm deep (D1) significantly excelled over other categories in terms of germinability parameter viz., number days for initiation of germination (14.67 days) and seedling growth trait viz., root length (14.98 cm) and shoot length (12.17 cm).

Results demonstrate that the seed sowing depth have a remarkable effect on seedling emergence and plant growth. Maximum emergence, best germinability parameters and growth was observed when seeds were sown at 1 cm depth. Large size seed (S1) of dark brown color (C2) showed maximum germinability parameters and seedling growth traits.

Keywords: *Germination parameters, seedling growth traits.*

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DIVERSIFYING SILVICULTURE IN MIXED FOREST OF *NOTHOFAGUS DOMBEYI*, *N. ALPINA* AND *N. OBLIQUA* THROUGHOUT THE FOREST LANDSCAPE

Georgina Sola*

Openings in the canopy due to harvesting practices constitute a disturbance that changes the environmental conditions of microsites, with effects on the relative performance of seedlings of different species. In mixed *Nothofagus* forest of *N. dombeyi*, *N. alpina* and *N. obliqua* of the Lanín National Reserve (LNR, Neuquén province) from Argentina, the same silvicultural system (shelterwood system) has been applied since late 1980 in spite of been localized in a W-E precipitation gradient. In previous studies we found that at local scale, regeneration showed not only greater dominance but also earlier establishment in sheltered microsites with less competition from understory species. *N. alpina* saplings represented a minority of post-harvest regeneration, while this species dominated in mature trees. At regional scale, changes in species abundance between adults and regeneration were also detected, and regeneration establishment was lower in mesic sites. Available data suggests that forest management systems should diversify silvicultural practices throughout the forest landscape, generating at each site the micro-environmental establishment conditions required by each species, in order to maintain biodiversity and forest functions. However, no reference framework exists until now to guide experimental design and scientific research on this subject. Therefore, we elaborated a reference diagram flow for silvicultural management of *Nothofagus* mixed forests based on previous results and considering stand structure, presence of advance regeneration, reproduction systems and landscape heterogeneity. This reference framework resulted in establishing ‘benchmarks’ with demographic and ecological information useful in decision-making. Further research into understanding landscape dynamics will be an important part of the framework that is required for the successful use of this data to help make conservation decisions concerning areas, landscapes and species.

Keywords: *Silvicultural prescriptions, regeneration, species composition, mixed forest, micro-environmental conditions.*

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HOW DO COMMERCIAL PLANTATIONS DEVELOPING IN AGRICULTURAL LANDSCAPE MATRICES AFFECT BIRD COMMUNITY COMPOSITION OF THE NATURAL GRASSLAND AND SUBTROPICAL FOREST?

Anahí Sofía Vaccaro* and María Isabel Bellocq

To assess the impact of forestry on biodiversity, it is relevant to consider the natural landscape matrix where commercial plantations develop. In landscapes where native forest is the natural matrix, as opposed to open habitats, commercial plantations are low-contrast patches and then less detrimental to native birds than other anthropogenic habitat types. In South America, although the original landscape matrix of the Pampean Grasslands (PG) and the Atlantic Forest (AF) were different, currently are both highly degraded due to agriculture. The objective was to analyze the similarity of bird community composition between tree plantations (TP) and protected areas (PA) of the PG (in Argentina) and the AF (in Paraguay). Despite the agricultural landscape matrix, we expected the similarity to be higher in the AF than in the PG, because TP are more similar environmentally to subtropical forests than to grasslands. Birds were surveyed in 6 TP and 3 PA sites in the PG, and 5 TP and 3 PA sites in the AF. At each site, we surveyed 10 observation points with a fixed 50-m radius during the breeding season. Contrary to our expectations, similarity of bird communities between TP and PA was higher in the PG than in the AF, but with non-significant differences ($F_{1,9}=2.063$, $p=0.185$). The relatively low similarity between TP and PA

in the AF may be partially explained for bird species present in TP but absent in PA. Some of those species are likely present in the agricultural landscape matrix. TP and PA in the PG shared more species than we expected. To preserve native bird species in the AF, we recommend to promote corridors between TP and the natural forest. In both biomes, the number and quality of PA should increase.

Keywords: *Commercial plantations, bird community composition, Pampean Grassland, Atlantic Forest.*

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ECOLOGICAL SUSTAINABILITY OF A FOREST PLANTATION BASED ON SPECIES DIVERSITY ALONG GRADIENTS OF LAND USE AND VEGETATION: A MULTIVARIATE APPROACH

A. Dezzotti*, A. Mortoro, H. Attis Beltrán, A. Medina and R. Sbrancia

Ecologically sound forest management should be based on the understanding of natural patterns of diversity and the ecological processes that influence these patterns. Species diversity as a key indicator for ecosystem functioning, stability and resilience, should be accurately measured to assess how is affected by human activities, natural disturbance, and spatial and temporal variation in environmental condition and gradients. We assess the environmental sustainability of a *Pinus ponderosa* (Pinaceae) afforestation located in a forest station at ~38° W and 71° S, based on diversity baseline of plants along contrasting landscape units, and Principal Component Analysis (PCA). We identified 13 natural and anthropogenic landscape units comprising degraded areas, steppes, meadows, natural woodlands and forests, 154 vascular plants, and 3 classes of pine stands (open, intermediated and closed). For evaluation, parameters were mean (S) and total richness St, α -, β - and γ - diversity (D), evenness (E) and species density (c). The first component of PCA (1) explained 60.3 % of accumulated variance (eigenvalue = 4.21), and the second (2) 86.6 % (eigenvalue = 1.84). For (1), the largest parameter weights were S, St, D α and D β ., whereas for (2), E and D β . The bi-dimensional graph split units into 5 groups: 1 (degraded area), 2 (intermediate and close stands), 3 (woodland and mixed forest), 4 (pure forest, steppe, rocky outcrop and open stand) and 5 (wetland). Open stand clearly separated from the intermediate and closed stands, resembling natural pure forest. Within these natural and anthropogenic habitats, diversity maintenance of plantations requires an open structure, which involve silvicultural prescriptions at stand and landscape levels mainly directed to reduce both, canopy cover and homogeneity. While such a management may represent a plantation with a lower timber production, it would exhibit a larger ecosystem and aesthetic value increasing the possibility of economically support by society.

Keywords: *Pinus ponderosa, Principal Component Analysis, Simpson diversity indices, vascular plants.*

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INDIGENOUS FOREST AND BIO-DIVERSITY PROTECTION SYSTEM IN RAJASTHAN (INDIA)

Kamal Narain Joshi*

Rajasthan has unique characteristics in terms of its climate and topography. About 60% of Rajasthan (western part) has a harsh climate and desert topography. The area is characterized by low and erratic rainfall, high evaporation loss and extremes of seasonal temperatures. Topographically, the area is covered by vast sand dunes and inter-dunes, scattered hillocks and saline depressions. Droughts are very frequent in this region. In such a harsh condition where nature does not support vegetation to grow, the community had evolved their own indigenous system to protect the forest and wild life dependent on it. They linked the system with culture and religion so that it could sustain for time to come without any support from the government. In different ceo-system Rajasthan it was known by different names. In the western, it is known as Oran, whereas in Aravali it is Kesar Chhata and in Alwar it is Dev Bani. In some places it is Pavitra Kunjs (Sacred Groves). In this system, a piece of land of natural vegetation was protected in the name of any god or goddess by villagers for their own specific need. Thus it was dedicated to one or more deities worshipped. The cutting of trees and grazing of animals in them was prohibited. Only dead and fallen trees were allow to remove for religious work such as the repair of the temple or funerals etc. This permitted natural regeneration of the forest land. These systems still provide shelter to wildlife and birds. In many of these orans one can expect old and mature local species of trees. During drought period these forests are only the source of fodder for the local cattle and shelter for wild life.

Unfortunately, This traditional community governance system these protected forests are also degrading and subject to encroachments. Hence there is an urgent need to rejuvenate the tradition to protect and regenerate the forest and biodiversity of the area.

Keywords: *Drought, indigenous system, Oran, forest, biodiversity.*

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ANALYSIS OF CHANGE IN WILDLIFE DIVERSITY THROUGH COMMUNITY FORESTRY

Damodar Gaire*

The main aim of the study was to identify and examine the change in mammal's diversity, avifauna diversity and insect's diversity due to the management of community forest. Two community forests named Chakratirtha Community Forest (CCF) and Bhalayekharka Community Forest (BCF) were selected in such a way that Chakratirtha community forest has been managed for 14 years as community-managed forest whereas Bhalayekharka community forests for only 5 years. Total of 14 mammals, 46 birds, and 33 Insects species was recorded during the study period. Chakratirtha CF received more record of mammals and birds, however, 11 mammals, 40 birds, and all insects were common in both Community Forests. Among the 46 recorded bird species, the relative abundance of 33 species of birds was higher in Bhalayekharka Community Forest and that of the remaining 13 species was higher in Chakratirtha Community Forest respectively. There was the significant difference between two community forests in terms of years of management. The study recommends the landscape level study on wildlife aspect in the Community Forest. Formulation of policy, production of separate guideline and field protocol, emphasizing wildlife conservation in Community Forests and assessment of wildlife outside the protected area should be initiated continually. However, re-survey of insects and further study of

birds is needed at the moment. Immediate action is needed to raise awareness about wildlife and to create provision of wildlife conservation in Operation Plan of Community Forest User Groups.

Keywords: *Wildlife diversity, community forest, species richness, relative abundance.*

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UPSTREAM ACTION, DOWNSTREAM IMPACT: LINKING LANDSCAPES FOR BIODIVERSITY CONSERVATION

Dhananjaya Lamichhane*

Nepal's rich biodiversity ranges from subtropical lowland to the Himalayan alpine region and has significant upstream and downstream linkages of watersheds. The paper discusses about the human activities carried out in the upstream mountains and their impacts on downstream flatland having rich biodiversity especially endangered species of wildlife and their natural habitats. The study was conducted in the Terai Arc Landscape (TAL) area in view of formulating a new strategy for the landscape-level management. Systematic and comprehensive biophysical and socio-economic data were collected and analyzed in relation to flooding from streams/ rivers flowing through mountains during the rainy season. Impacts on biodiversity in three aspects, viz. landscape fragmentation, habitat degradation and loss of species were examined. The findings show that widening of river courses were due to recurrent flood sediments that created no-vegetation area in the continuum of landscape. Flash floods killed the endangered species such as rhino and tiger, with significant damages to grass and tree cover, which disturbed prey-predators behaviors. Timelines and storytelling socioeconomic surveys revealed the fact that upstream development activities such as excavation of roads, collection of sand stones and forest fire incidents were most responsible for unprecedented flooding in the downstream. The streams were all dried-up during winter and summer seasons. The results from biophysical data analysis showed that the maximum riverbed rise was 5-15 cm and the riverbed widening was 5-10 meters. Flooded area damaged 90% of grass, 30-65 % shrubs and 10-20 % of trees. And the restoration rate was higher in shrub, followed by grass and tree. Watershed-based south-north perpendicular landscape linkages were critical to sustain the biodiversity of east -west TAL area. Streamflow management was recommended as the best alternative to establish a good upstream/downstream linkage for effective biodiversity.

Keywords: *Landscape, biodiversity, upstream, downstream, species.*

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Session 1.7

Monitoring biodiversity in forested landscapes: a key component in the adaptive management

Chair: Gustavo A. Zurita

MAPPING AND MONITORING VILLAGE-LEVEL USE OF COMMUNITY FORESTS IN RURAL DEMOCRATIC REPUBLIC OF THE CONGO: IMPLICATIONS FOR FOREST LANDSCAPE SUSTAINABLE

Adeloui Hugues Akpona*, Janet Nackoney, Charly Facheux,
Jean Claude Kalemba and Antoine Tabu Senga

This study seeks to inform methods for both land planners and local communities for participating in land use planning processes in the DRC while also increasing understanding of village-level use of community forests, which is not well understood in this area due to its relative isolation, lack of land tenure, and lack of demographic data collected. We developed a method that trained and guided village representatives through a collaborative process to map the geographic boundaries of their respective community forests. We also collected demographic and socio-cultural data on village human population size; assessed how many hectares of community forest land were used per person at the village scale, and whether this number was spatially consistent for all villages across the study area. We compare how the forests, including any inundated swamp forests found within, were used by the communities from a human livelihoods and cultural perspective. We also calculated the maximum distance that the forest concession boundaries extended from the villages' settled areas in order to better understand the farthest extent that the villagers might travel in order to access their forests. Finally, we assessed the amount of tree cover loss taking place within the concessions, which is usually a result of agricultural expansion, analyzed the spatio-temporal patterns of observed tree cover loss, and tested whether a significant relationship existed between the amount of tree cover loss and the size of the villages' human population as well as the villages' total amount of land used for agricultural activity. We noted several observations and key points learned from the mapping experiences and developed recommendations for employing these participatory mapping methods in this region. We demonstrate how the participatory delineation of the villages' community forest boundaries can serve as an essential first step for strengthening local capacity for land-use planning in DRC.

Keywords: *Landscape, land use planning, forest protection.*

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RECOVERY COMPLETENESS AFTER NATURAL REGENERATION OF THREATENED MEDITERRANEAN FORESTS IN CHILE

Adison Altamirano*, Alejandro Miranda, José María Rey-Benayas,
Germán Catalán and Marco Prado

To promote the natural forest recovery is a cost-effective method to tackle the urgent global task of forest restoration. However, the variation of attributes that indicate the recovery outcomes depend on environmental gradients, thus representing a relevant issue for large-scale and cost-effective forest restoration goals. We studied natural forest recovery of degraded Mediterranean forests of Chile. In particular we assessed the forest recovery completeness using field data from regeneration and reference plots (baseline) and aerial imagery, climate, topography, and soil information. We selected five indicators to estimate the recovery completeness: basal area (BA), quadratic mean diameter (QMD), adult species density (ASD), adult species richness (ASR), and seedlings species richness (SSR). We fit spatial models to predict the recovery completeness using response ratios of each recovery indicator. Overall, tendency of recovery completeness showed a trajectory towards the reference, thus hinting a positive prospect for attaining fully restored forests. However, recovery completeness showed high variation among the indicators; BA (33%) and QMD (61%) attained the lowest levels, whereas diversity indicators (ASR and SSR) and ASD showed the highest levels of recovery completeness (92%, 99% and 77% respectively).

Predictions of recovery completeness over the landscape also showed marked different spatial patterns, which were dominated by the intermediate category of recovery completeness that represented an average of 727,263 ha (56% of the landscape). We observed low spatial congruence among recovery indicators. The maximum spatial congruence for high recovery completeness values was found in 592 ha only (0.05% of the landscape). The main variables affecting the recovery completeness were distance to coast, aridity index, and mean temperature of the driest quarter. We conclude that the goals of forest restoration projects are critical to establish how measure the project success through recovery completeness indicators. However, restoration projects that address the multifunctionality of landscapes lead to consider different indicators of recovery completeness.

Keywords: *Forest restoration, passive restoration, boosted regression tree, native forest.*

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BIOTIC INTEGRITY FOR REMNANTS OF SEMI-DECIDUOUS SEASONAL FOREST IN URBAN LANDSCAPES

Fabricio Macedo Galvani and Eliana Cardoso-Leite*

In Brazil, semi-deciduous seasonal forest (SSF) is one of the physiognomies of Atlantic Forests, and sited between the Atlantic Forest and Savanna Biomes. Over the last decades, SSF has been fragmented by use of the soil for agricultural or urban areas. The urban and industrial growth promote a strong impact in forest fragments due to the edge effects, isolation, and habitat degradation. Hence, the knowledge about ecologic dynamics and biotic integrity inside this fragment is essential to guide public policy and to support decision makers, in the planning and management of territories. The goal of this study was to analyze the Biotic Integrity in fragments of SSF inside Ribeirão Preto (SP), a medium-sized city in the southeast of Brazil, and to analyse the relationship between BII and landscape metrics (size, shape and connectivity). The method (BII) has nine indicators (littler and grass cover, stand of dead trees, exotic wood species, vines, gaps in the canopy, vascular epiphytes, later species in canopy and in understory). The results can vary from 9 to 45. The survey was carried out in 9 forest fragments, the sizes of which are from 1.3 to 185,0 ha, all with urban influence. The relation between IBI and landscape metrics (size, shape) were analyzed by the Pearson correlation. BII value were registered from 26.0 to 38.0 or as low, medium or high integrity. The results showed strong correlation between IBB and size ($p= 0.7944$), and weakness with shape ($p= 0.47$). Therefore, the results show a vast area (77 ha) with low Integrity and another small area (22 ha) with high integrity. It was registered a medium-sized area, with high integrity located urban area in expansion, for which it was recommended the creation of one Protected Area.

Keywords: *Protected areas, urban planning, biotic integrity index.*

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THE IMPACT OF CORDGRASS INVASION ON MANGROVE FOREST IN COASTAL CHINA

Ke-Ming MA* and Quan Chen

The exotic cordgrass (*Spartina alterniflora*) was introduced into China in 1970s from its original region the North America. Now it distributes over 100 000 ha in area, and covered more than half of the coastal China, which brought an economic loss over 100 billion RMB per year. Moreover, it has many kinds of ecological impacts on the coastal mangrove forest ecosystem. It improves the plant individual density and the biomass of the community and the nutrient level in soil, which caused a decreasing in the quantity and biomass of Macroenthic Fauna and the diversity of seabird. Meanwhile, the cordgrass has become a main food resource of many Macroenthic Fauna, which means it has successfully invaded into the food web of the ecosystem.

Keywords: *Cordgrass, mangrove forest, Macroenthic Fauna, sea bird, food web.*

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THERE ARE MUCH MORE RARE TREE SPECIES IN SECONDARY ATLANTIC FORESTS THAN IT WAS THOUGHT: A TREE RARITY ASSESSMENT USING SYSTEMATICALLY GATHERED DATA

Laio Zimermann Oliveira*

Usually, biodiverse forests are composed by several tree species with reduced abundance and/or small occurrence area. Thus, these rare species carry with them a sense of uniqueness and increased risk of extinction. In this context, we sought to classify 646 tree species occurring in three forest types within the Brazilian subtropical Atlantic Forest hotspot into seven rarity forms encompassing population size, habitat preference, and geographical distribution. In addition, we investigated the behavior of different sample sizes on the outcomes of rarity classification through a resampling technique. We employed data collected within 418 0.4 ha systematically distributed sample plots. From the 646 recorded species, 67.3% were classified into one of the seven rarity forms at least in one forest type. In turn, about 50% of the species found in each forest type were rare. Myrtaceae was the family with the greatest number of rare species, followed by Fabaceae, Lauraceae, and Melastomataceae. Yet, rare species represented a diminished portion of the ~90,000 sampled individuals: less than 5% of the trees in each forest type. Species with scarce populations (≤ 10 trees)—i.e., forms 1, 3 and 7—represented more than 40% of the total species richness recorded in each forest type. Sample plots installed in old-growth stands, ecotone areas, or areas with particular environmental features (e.g., hydromorphic soils), often presented larger proportions of rare species. Public protected areas shelter some singleton species. Quadratic plateau regression models brought up evidence that the mean proportion of recorded rare species did not increase substantially in sample size classes greater than 70-80% of the reference sample. The rarity forms comprising scarce populations were shown to be particularly influenced by sample size if compared to the other rarity forms. In fact, the form 7—the most restrictive one—was considerably influenced by different sample sizes in all forest types.

Keywords: *Threatened species, endemism, Araucaria forest, rain forest.*

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RIPARIAN VEGETATION DYNAMICS ACROSS FOREST AND AGRO-ECOSYSTEM LANDSCAPES OF RIVER CAUVERY, SOUTH INDIA

Nagaraja BC* and C. Sunil

Riparian forests have received much attention in the recent years and attracted international concern due to their role in providing many ecosystem services such as preventing soil erosion, minimizing floods, enhancing wildlife corridor, habitat for endemic species, etc. The present study aims to examine tree species richness, and composition and diversity of riparian forests across forest and agro-ecosystem landscapes observed along the river Cauvery of southern India. Riparian forest was sampled in a belt transect of size 100 × 50 m, at each of the 80 sampling plots scattered over a 318 km length along the river Cauvery. Total of 177 tree species belonging to 52 families, representing 2930 individuals, were recorded. Differences occurred between the forest and agro ecosystem landscape in terms of species richness, family richness and number of individuals observed, with a decrease in agro-ecosystem compared to forest landscape. Species similarity was low between the forest and agro-ecosystem landscapes. The Shannon-Wiener diversity index was higher for forest landscape (5.6) with more evenness in distribution. In the forest landscape, high importance value indices (IVI) were obtained for *Terminalia arjuna*, *Pongamia pinnata* and *Hopea parviflora*. In the agro-ecosystem, species such as *Pongamia pinnata*, *Ficus benghalensis* and *Salix tetraspermae* exhibited high IVI.

Expansion of agricultural activities and other biotic pressures might have led to the variation in species composition between the forest and agro-ecosystem landscapes. Also, it has led to the decline in ripicole and evergreen species such as *Hydnocarpus pentandra*, *Elaeocarpus tuberculatus*, *Madhuca neriifolia*, *Palaquium ellipticum*, *Myristica dactyloides*, etc., consequently affecting the associated biodiversity of the river in the agro-ecosystem. Country needs to enact a permanent policy to protect and conserve riparian buffers to avoid further degradation and loss of biodiversity in the unregulated areas along the river.

Keywords: *Biodiversity, Western Ghats, riparian forest, agro-ecosystem, landscapes.*

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RESPONSES OF BIRD DIVERSITY TO EUCALYPT CHRONOSEQUENCE IN THE MESOPOTAMIC PAMPA OF ARGENTINA

Pamela E. Pairo*, Pablo Aceñolaza and M. Isabel Bellocq

Major human transformations of landscapes typically result in significant changes in biodiversity. Eucalypt plantations are expanding in Argentina particularly in the Mesopotamic Pampa, with little evidence about impacts on bird communities. Recognizing the rapid structural and microclimatic changes that occur during eucalypt plantation growth, this work is aimed to describe the alpha (species richness) and beta (dissimilarity in species composition between sites) diversity of avian community along the eucalypt chronosequence in a grassland biome, and their relationship with environmental variables. We selected plantations of eight ages and three replicates per age. Additionally, we surveyed three protected grasslands as the reference habitat. At each replicate, birds were sampled using a point count method and environmental variables were measured (% canopy, average tree height, % herbs and plantation density). To estimate beta diversity we used both incidence (Sorensen index) and abundance-based (Bray Curtis index) dissimilarity index. The Sorensen dissimilarity index can be partitioned into species replacement and nestedness, whereas the Bray Curtis dissimilarity index can be partitioned into balanced variation in abundance (individuals of some species substituted by the same number of individuals of different species) and abundance gradients (some individuals are lost from one site to the

other). GLM Poisson indicates that along the eucalypt chronosequence, species richness decreased with average tree height and %herbs. Furthermore, nestedness and abundance gradient are the most relevant components of taxonomic dissimilarities and increased along the eucalypt chronosequence, reflecting the loss of bird species and some individuals of those species. Our results indicate that avian communities are negatively affected by eucalypt plantations developing in the Pampean grasslands, which may lead to reduce the provision of ecosystem services if the spatial extent of plantations continues.

Keywords: *Eucalypt plantation; bird communities, chronosequence, beta diversity, alpha diversity.*

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FINE-SCALE SPATIAL GENETIC STRUCTURE STUDY IN CONTRASTING LANDSCAPES AS A TOOL FOR MAKE MANAGEMENT DECISIONS IN NATIVE FORESTS: THE CASE OF CEBIL

A. L. Goncalves*, M. E. Barrandeguy, M. C. Escalada and M. V. García

Fine-scale spatial genetic structure (FSGS) in plants is mainly determined by the pollen and seed dispersal, which is strongly affected by both evolutionary and ecological processes. FSGS studies in forest tree species allow evaluating the influences of landscape configuration on pollen and seed movement. Here, we compared FSGS among natural populations of a native forest tree species *Anadenanthera colubrina* var. *cebil*, locally known as cebil. Populations are localized in Santa Ana (SA) (Paranaense phytogeographic province) and Calilegua National Park (CL) (Yungas phytogeographic province). SA population is located in a highly fragmented landscape in contrast to the relatively continuous landscape where CL population is located. Eight specific microsatellite markers were used to genotype 68 adult individuals. FSGS was evaluated based on pairwise kinship coefficients (F_{ij}) at different distance classes. F_{ij} was positive and significantly different than expected at random only at first distance class (up to 154m) in CL population. In SA population fragments, the kinship was significantly different than expected at random in the most of distance classes. In this sense, FSGS of SA was higher and stronger rather than FSGS of CL ($F_1(SA)=0.077$ and $F_1(CL)=0.044$; $Sp(SA)=0.022$ and $Sp(CL)=0.016$). These results might be explained by restricted dispersal that generates familiar units and spatial structure at the patch level in SA. The inbreeding coefficient was markedly higher in SA than CL ($F_{IS}=0.34$ and 0.15 , respectively) as a consequence of an increase in the levels of mating between relatives within patches in the fragmented landscape. The results of this work are relevant to make management decisions, being ~154m a minimal distance of forested landscapes needed to maintain genetic connectivity among natural populations of *A. colubrina* var. *cebil*.

Keywords: *Spatial genetic structure, Anadenanthera colubrina var. cebil, genetic diversity; molecular markers, microsatellites.*

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SPECIES DIVERSITY AND TIMBER PRODUCTION IN A PLANTATION FROM PATAGONIA OF ARGENTINA: A CASE STUDY AT MANAGEMENT UNIT LEVEL

H. Attis Beltrán* and A. Dezzotti

Species diversity and productivity are key indicators of ecosystem integrity for forest management. Although plantations of exotic trees provide essential goods and services, they diminish plant and animal richness when constitute even-aged monocultures of large density. We evaluated the sustainability of a *Pinus ponderosa* (Pinaceae) plantation in “El Retiro” (40° 05' S - 71° 12' W), based in these indicators. Here, winter is cold and wet and summer is warm and dry. Lithology comprised basalts and andesites covered by Holocene tephra, and soils were Andisols. Vegetation corresponded to the semiarid steppe - temperate forest ecotone. Stands were established 25 yr ago in the steppe and ecotone. We selected three structural categories of stands for sampling: open (PO, Reineke's Stand Density Index SDI < 500), intermediate (PI, SDI = 500 - 800) and closed (PC, SDI > 800). In these stands and also in the surrounding steppe, as the reference community (RC), diversity of vascular plants was estimated through incidence presence / absence data and Simpson indices. Timber production was assessed using the "Piltriquitrón 3.0" model for a 40 yr- rotation. In RC, PO, PI and PC diversity was 4.8, 3.5, 1.4 and 1.0, respectively, and richness was 9.0, 8.0, 4.7 and 1.8, respectively. Final timber production was predicted for PO = 462.4, PI = 795.2 and PC = 784.3 m³/ha. All values significantly differed among units (p < 0.05). Diversity in PO was equivalent to that in RC. PC showed the lowest diversity whereas its production was similar to that in PI. The best management option for conserving plant diversity and producing timber would be attained with a slightly less SDI than that of PI. Understanding ecological processes involved in the negative correlation between production and diversity are crucial to implement sustainability scenarios in these anthropogenic habitats.

Keywords: *Pinus ponderosa*, Simpson diversity indices, vascular plants.

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Session 1.8

Agroforestry: building relationships
between human populations and nature
to make forest and agricultural
landscapes sustainable

Chairs: Jo Smith, Anastasia Pantera,
João Palma and Gerardo Moreno

EXAMINING THE LIKELIHOOD OF AGROFORESTRY ADOPTION WITH RESPECT TO CONVENTIONAL AGRICULTURE IN DHANUSHA DISTRICT OF NEPAL: AN ECONOMETRIC ANALYSIS

Arun Dhakal* and Rajesh Kumar Rai

Agricultural land degradation has reduced agricultural productivity in Nepal's terai. This has raised concern over the viability of current conventional agriculture of the terai farming system. Agroforestry can be a potential solution to the above problem. This paper aims at identifying factors affecting adoption of agroforestry, a tree-based farming system, with respect to conventional agriculture. Necessary data were collected from a survey of 288 households through a face-to-face interview with household heads from nine village development committees of Dhanusha district, Nepal. Farming systems in the study area were grouped into three distinct categories: agroforest system/Wood-lot (AFS), Alley cropping system (ACS) and conventional agricultural system (CAS). A multinomial logistic regression (MNL) was run with conventional agriculture as a base category. The results showed that sex of household head, off-farm income, size of private land, livestock herd size, extension service, home-to-nearest government forest, irrigation facility, membership and awareness had significantly positive effects while home-to-highway distance, family size (economically active family members) and risk-averse had significantly negative effects on adoption of a tree-based farming system. A male-headed household having a source of off-farm income and irrigation facility, locating far from the nearest forest and aware of the environmental benefits of agroforestry are more likely to adopt the tree-based farming system.

Keywords: *Agroforestry adoption, terai farming system, multinomial logistic regression, Nepal.*

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LANDSCAPE RESTORATION IN A MIXED AGRICULTURAL-FOREST CATCHMENT: PLANNING A BUFFER STRIP AND HEDGEROW NETWORK IN A CHILEAN BIODIVERSITY HOTSPOT

Alejandro Miranda*, José M. Rey Benayas, Adison Altamirano, German Catalan, Marco Prado, Fulgencio Lisón and James Bullock

The positive impact of natural or semi-natural linear vegetation elements for biodiversity and ecosystem services is well documented. However, guidance for large-scale restoration of such features is often lacking. Focusing on a Chilean biodiversity hotspot, this study develops a plan for a buffer strip and hedgerow network at the field, landscape, and catchment scale as a step towards cost-effective restoration. We present seven general guidelines for buffer strip and hedgerow restoration that stem from ecological principles, the scientific evidence, and our 10-year experience as practitioners, and tailor these to a case study in the Valdivian Rainforest Ecoregion. We assessed the landscape in terms of the existing woody vegetation elements, proposed a buffer strip and hedgerow network considering landscape spatial analysis, field surveys, prioritization criteria, and seedling availability in the region's nurseries, and estimated the budget for implementing the proposed network. Buffer strips and hedgerows comprised on average 5.1 and 20.9 m ha⁻¹, respectively. The forest remnants, tree plantations, and tree lines provided 20.4, 6.1 and 5.31 m ha⁻¹, respectively, of woody edges to the fields. Woody plant communities comprised 33 shrub and tree species, of which 13 (39.4%) were exotic. Mean species richness and mean density per 20x3-m plot were 1.74 ± 1.12 (SD) species and 6.13 ± 5.78 individuals, respectively. A total of 2,040 ha of buffer strips must be restored in the catchment by Chilean law. A relatively low proportion of fields, ranging between 14.5% and 31.3% in three

representative agricultural landscapes, did not meet our target of 5% area of existing native woody vegetation elements. The average estimated cost of buffer strip plantings was USD 7,396 ha⁻¹ and of hedgerows ranged between USD 6,619 and USD 7,169 ha⁻¹. Financial incentives, education, and professional training of farmers are identified as key issues to implement the suggested restoration actions.

Keywords: *Ecosystem services, guidelines, land-sharing.*

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ADAPTATIVE FARM MANAGEMENT IN THE CONTEXT OF THE EXPANSIONS OF INDUSTRIAL FOREST PLANTATIONS IN MISIONES, ARGENTINA

Lucía Cariola*, Antonio De la Peña García and Norma Hilgert

Industrial forest plantation (IFP) in Argentina has grown 90% in extension between 1990 and 2010, reaching 1.2 million ha today. The Province of Misiones hosts more than 30% of that area. While large and medium-size corporations directly own the majority of IFPs, small-scale producers in Misiones have adopted industrial forest production as part of an adaptive farming management strategy (AFMS). We examine the farming strategies of Colonos (settlers or colonists in Spanish), a specific type of small-scale producer in northwest Misiones that has adopted IFP as a part of historical strategy of mixing commercial crops for the market with an agrobiodiverse management of their lands. The north-western Misiones landscape in which Colono farms exist is immersed in models of IFPs of different scale. They go from large, continuous blocks that surround Colono properties, to discontinuous ones owned by Colonos themselves. In this context, we hypothesize that Colono AFMS would be affected by the type of forestry model in which they are located. We show preliminary results from 58 semi-structured interviews in 5 communities located in different IFP models on topics related to perceived personal and regional changes in farm production through time. In addition, field visits and interviews with 37 informants were carried out to quantify the richness and abundance of Colono farms under different IFP models. The objective was to understand a possible relation between IFP models and adaptive changes by producers. The results show significant differences in abundance in farms according to their location in different IFP models. Colono farms in matrixes dominated by large, continuous IFP blocks show greater multifunctionality of farming and multiplicity of crops both for household consumption and the market. Farms in less IFP dense production models show significant richness of spaces, although size of the farm is a variable that requires special consideration.

Keywords: *Adaptive farm systems, Misiones, Industrial forest plantations, agrobiodiversity, Colonos.*

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INDICATORS OF ECOSYSTEM SERVICES IN SILVOPASTORAL SYSTEMS IN THE LA VIEJA RIVER BASIN, QUINDÍO – VALLE DE LA CUENCA – COLOMBIA

Antonio Solarte*, Elena Velasquez and Patrick Lavelle

Silvopastoral Systems (SSP) contribute to the agro-ecological intensification of livestock. The Payment for Ecosystem Services (PSE) has been useful to facilitate these processes. However, it is necessary to have evidence of the benefits of the SSP on Ecosystem Services (SE), at various

scales and the role played by the PSE. Data from the Regional Project Silvopastoral Approaches for the Management of Ecosystems, allowed to analyze changes of SE of carbon storage and conservation of biodiversity in 104 farms in the period 2003 to 2007, and 2011, for 75 farms with PSE paid for a period of 2 or 4 years and contrast it with a control group of 29 farms. A sample of 20 farms allowed to evaluate indicators for SE of the soil in 2013, including: physical, chemical, organic matter (OM), soil organic carbon (SOC) storage in 0 to 15 cm, macro-aggregation, and macrofauna, in: forests, pastures with trees, pastures without trees, intensive silvopastoral system (SSPI) and crops. In this same sample, an indicator for landscape change was evaluated in the period 2003 to 2011 with high resolution satellite images and metrics. The results shown that the PSE for 2 and 4 years contributed to improve the ES related to carbon storage and conservation of biodiversity in the evaluated period. SSPi and pastures with trees had a positive effect on sub-indicators such as chemical fertility, COS, MO and morphology, related to the activity of the macrofauna. The indicator of change in the landscape had high correlation with the carbon and biodiversity indicators. The PSE proved to improve SE at several scales at the scale of farms and landscape, contributing to the sustainability of cattle ranching.

Keywords: *Ecosystem services indicators, ecological intensification, ecosystem services, sustainable livestock, silvopastoral systems.*

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RESEARCH IN AGROFORESTRY: THE AGFORWARD PROJECT IN GREECE

Anastasia Pantera*, Andreas Papadopoulos, Konstantinos Mantzanas,
Vasileios Papanastasis and Georgios Fotiadis

AGFORWARD (AGroFORestrythatWillAdvanceRuralDevelopment) was a four-year research program funded by EU Seventh Framework Program for Research and Technological Development (FP7). It commenced in January 2014 and was completed in December 2017. The project included agroforestry experiments and on-site field tests. The overall objective of the project was to promote agroforestry practices in Europe that will contribute to rural development, ie to improve competitiveness and the social and natural environment. TEI of Stereas Elladas participated in the project aiming to investigate the integration of other crops and / or animals into olives and orchards as well as the research of oak bark beetles. This article presents the Greek experimental sites, the general results of the experiments as well as a discussion on the opportunities regarding agroforestry in Greece.

Keywords: *Olive groves, intercropping, orange orchards.*

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PERCEIVED VALUES OF AGROFORESTRY LANDSCAPES IN DIFFERENT EUROPEAN CONTEXTS: WHAT MATTERS AND FOR WHOM?

Marine Elbakidze*, Diana Surova, José Muñoz-Rojas,
Teresa Pinto-Correia and Tobias Plieninger

Agroforestry is considered as a multifunctional land use system that fosters the sustainable provision of multiple ecosystem services while not compromising agricultural and forestry productivity. However, despite a number of measures in place for their sustainability, agroforestry landscapes are in a sharp decline across Europe, both qualitatively and quantitatively. To develop context-specific policies and management interventions, a pluralistic value approach is required,

which is essential to generate evidence-based knowledge on the societal relevance of these landscapes in different contexts. This study assesses and compares the values that people attribute to agroforestry landscapes across different countries and regions in Europe, based on case studies in Portugal, Sweden, Latvia, Belarus and Russia. We applied the Multiple-Value approach, which is an integral conceptual component of the Intergovernmental Platform on Biodiversity and Ecosystem Services. In total 2120 face-to-face structured interviews were conducted across the five aforementioned countries. Results were then analyzed using SPSS 24.0. Results show that the majority of respondents in each country considered agroforestry landscapes as important for their wellbeing. Three dominant types of societal appreciation of agroforestry landscapes were identified. (1) The hedonistic type, which is based mainly on relational values. Under this type, agroforestry landscapes are perceived as a space for leisure and recreation due to their beauty and attractiveness. (2) The utilitarian type that encompass mainly instrumental values. This entails that tangible products associated with self-subsistence or commercial land management ought to be prioritised. (3) The pluralistic type that is based on the multiple values of agroforestry landscapes, including intrinsic values. A general trend is found in the distribution of dominant types of perceptions across Europe: from mainly hedonistic in the North, utilitarian in the East, and pluralistic in the West. Accordingly, we discuss policy options on how to mainstream contingent values of agroforestry landscapes at multiple levels.

Keywords: *Agroforestry; landscape appreciation; social values; Europe.*

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HURRICANE DISTURBANCE & RECOVERY: PUERTO RICO'S OPPORTUNITY TO PROMOTE RESILIENT AGRICULTURE LEARNING FROM CUBA'S AGROECOLOGY PRACTICES

Sara Santiago*

When Hurricanes Irma and Maria swept across the Caribbean in September 2017, they caused catastrophic damage to social and ecological landscapes alike, denuding Puerto Rico's forests and decimating farms at a time of deep economic depression on the island. While official reports and surveys of damage to Puerto Rico's farms are forthcoming, it has been estimated that 80% of agricultural crops were lost during Hurricane Maria, effectively wiping out the agriculture sector. Maria has thus created an opening to rethink land use practices in terms of resistance and resiliency against increasingly intense and frequent hurricanes. Meanwhile, over the past 30 years, neighboring Cuba has developed meticulous agroecological systems that are reported to be more resilient to hurricanes, which Puerto Rico may benefit from adopting more prevalently. This presentation will address this hypothesis, through a comparative study between Cuba and Puerto Rico's ecological and social preparedness, response, and agricultural recoveries from recent hurricane impacts. The information presented will be the result of interviews with representatives from government, NGOs, and academics as well as farmers on both islands. The intention is to inform Puerto Rico's recovery effort and strategy for agriculture development on a very urbanized yet highly forested island that must respect forest conservation and respond to rapid changes in the current economic and climatic instability.

Keywords: *Agroecology, hurricane, recovery, resiliency.*

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MULTI-SCALE DRIVERS AND MULTIPLE PATHWAYS TO CHINA'S FOREST TRANSITION

Lingchao Li*

Forest Transition theory has elucidated the multiple pathways through which countries embark on forest recovery over the last two centuries. However, countries undergoing a forest transition today are in a fundamentally different global context compared to even half a century ago. We analyze China's forest transition process to expand the theory in three ways. First, we undertake the analysis of sub-national outcomes to disentangle the multiple pathways through which forest transition takes place within one country. By analyzing the diversity of drivers and outcomes at the provincial level, we take an important step towards uncovering micro-causal explanations. Second, we investigate causal mechanisms that work across space, leading to a forest transition at the national level. Specifically, we identify mechanisms that operate across provinces within China, in addition to international factors. Third, we explore changes in both forest area and volume. Our results suggest that ecological concerns and public investments in forest improvement are important determinants of expansion of forest area. In parallel, increases in forest volume can be attributed to a complex chain of factors linking export-led economy and labor out-migration, through a reduction in forest dependence.

Keywords: *Reforestation; migration; exports; forestry policy.*

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EVALUATION OF REFORESTATION SUCCESS OF 1 NATIVE TREE SPECIES OF TROPICAL DRY FOREST IN CATTLE RANCHING LANDSCAPES IN THE AZUERO PENINSULA, PANAMA

Verónica Chang*, Jonas Lechner, Jacob Slusser and Florencia Montagnini

Comprehensive evaluation of reforestation success can assist reforestation project planning and support rural communities in developing countries to alleviate poverty and improve their livelihoods. The Azuero Peninsula is one of the most endangered and severely deforested territories of Panama. Anthropogenic drivers have exposed this tropical dry forest region to continuous degradation and loss of biodiversity and ecosystem services. Conventional cattle ranching practices have dominated this region, decreasing on-farm productivity. The Association of Livestock and Agro-Silvopastoral Producers of Pedasi (APASPE) has become a leader in implementing sustainable cattle ranching and forest restoration projects. The objective of this study was to evaluate the success of tropical dry forest reforestation with 19 native species, after 4 years of plantation through survival, growth, crown area, and biomass. Results of this study showed that for all indicators, agroforestry plantations performed better than conventional plantings. Mean survival was 33.25% greater in agroforestry than conventional plots. Average growth exhibited higher values in agroforestry sites. *Anacardium excelsum* showed high survival and growth rates among plots. *Albizia saman*, *Gliricidia sepium*, and *Anacardium excelsum* showed large crowns suggesting canopy closure before 5 years of establishment. Aboveground biomass reached an average of 4347.76 Kg/ha. These findings illustrate the performance of native

species in timber plantations and agroforestry systems, allowing for initial site-specific recommendations of potentially valuable species for restoration and other uses in tropical dry regions.

Keywords: *Reforestation, agroforestry, conventional, plantations, native species, survival, growth, crown area, biomass, tropical dry forest, cattle ranching, Azuero, Panama.*

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SUSTAINABLE USE OF ORCHIDS IN INDIGENOUS COMMUNITIES OF MISIONES – ARGENTINA

Patricia Rocha*, Evelyn Duarte, Peggy Thalmayr, Vanesa Mangeon, Manuel Radke, Fernando Niella and Marina Parra

The native orchids are an important resource of Misiones biodiversity, generally associated to an extractive, non-sustainable use, by the Guarani indigenous communities. Studying the local species with greater ornamental potentials and market value, together with the application of propagation and training techniques for indigenous communities members, is an alternative to achieve substantial progress towards the sustainable use of the resource. The objective of this present work, is to describe the objectives and activities of our project, aiming to generate and integrate knowledge on native orchid species with high market acceptance; and to train local actors (members of the indigenous communities), on propagation techniques, and on sustainable production of the orchids. It is expected to develop standardized technical bases for the replication of the activities in priority areas, as well as their incorporation in the provincial regulations for the sustainable use of the surveyed species.

To date, the priority orchid species to be propagated have been defined, the study of their requirements for germination and in vitro culture was started; and four participatory training workshops were held on different topics (definition of priority species, in vitro germination, acclimatization of orchids, and greenhouse design). Members of the Yvytú Porá community are being trained as a leading community, whom will be the responsible actors to transmit this knowledge to other stakeholders interested in starting the sustainable production of native orchids.

Keywords: *In vitro germination; acclimatization; propagation, knowledge integration.*

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ECOLOGY OF *COLA NITIDA* (VENT.) SCHOTT & ENDL AND *GARCINIA KOLA* HECKEL AND THEIR POTENTIALS FOR RECRUITMENT OF UNDERGROWTH SPECIES ACROSS TWO CLIMATIC GRADIENTS IN NIGERIA

Onyebuchi Patrick Agwu*

Cola nitida and *Garcinia kola* are indigenous multipurpose trees in West Africa that can contribute to regional and local income generation, strengthens food security, improves health care and increases carbon sequestration to fight climate change. This study on ecology of *Cola nitida* and *Garcinia kola* and their potentials for recruitment of undergrowth species across two climatic gradients in Nigeria was conducted in order to investigate the floral sociology and agroforestry suitability of *C. nitida* and *G. kola* with the aim of providing baseline information their habitats. The study was carried out in two vegetation zones in Nigeria namely, humid forest

zone and derived savanna. The data were collected by identifying and enumerating the plant species closely associated with the subject tree (*G. kola* and *C. nitida*) across their naturally occurrence in different ecosystem. Statistical analysis was done using percentages, frequency, graphs, diversity indices, diversity profile and diversity t-test. The results shows that a total of 84 plant species were found associated with *G. kola* in the rain forest zone, 71 plant species were encountered with *G. kola* in the derived savannah while a total of 72 and 54 plant species plant species were encountered associating with *C. nitida* in rain forest zone and in derived savannah respectively. Species are of high economic and medicinal values. The diversity t test shows that there are no statistical significant different between associated species encountered in the two distinct zone visited which indicated that the vegetation type does not influences the nature and species association. For successful establishment of agroforestry system, conservation options and the inherent agro-ecosystems services, *C. nitida* and *G. kola* have great potentials for recruitment of undergrowth and coexist freely with other species and could be used in agroforestry systems.

Keywords: *Floral sociology, agroforestry, Cola nitida, Garcinia kola, multipurpose trees.*

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OP 1.1

Forest landscapes: multiscale
modelling challenges and opportunities

Chair: João Azevedo

MONITORING AND DETECTION OF DEFORESTATION AND FOREST DEGRADATION IN SWAT, PAKISTAN BY USING FOREST MONITORING TECHNOLOGY: CLASLITE V 3.3.

Owais Syed Muhammad* and Saima Siddiqui

Deforestation and forest degradation is not only a problem of Hindukush Himalayan region of Pakistan but it is one of the main global environmental issues. This study examines modern tools to monitor and detect spatial and temporal forest cover changes in District Swat by using moderate resolution Landsat satellite imagery. To find out deforestation rate and its extent in Swat, Khyber Pakhtunkhwa, Carnegie Landsat Analysis System-lite was used. Landsat 5 (Oct2, 2011), Landsat 8 Operation Land Imager (Oct15, 2016) images were acquired from Earth Explorer and processed in CLASlite. The result indicated a rapid decrease in natural vegetation that is 11 square kilometer area was deforested and approximately 985 square kilometer area was degraded from 2011 to 2016 mostly in Lower Swat and a rapid increase in built-up area. Most of the deforestation patches persist within the administrative boundaries at tehsil level that is Babozai, Barikot, Kabal, Matta, and Khwazakhela. The results of the study also supported International studies which report a high rate of deforestation in the country. This study assessed that natural vegetation can be monitored by using recent forest monitoring technology, which is highly automated and user-friendly and can be processed by a number of satellite sensors like Landsat, SPOT, MODIS etc. One of the major consequences of deforestation is the total disappearances of Charchur waterfall in Talang Tehsil Barikot in September 2016. The mountain of lower Swat and adjoining areas is covered with the ever-thirsty *Eucalyptus*, which accelerates the current environmental crises like climate change and water depletion. Therefore it is the right time to move towards adaptation to climate change, monitoring of natural forest reserves by using modern geospatial tools and by the involvement of local communities in decision making about conservation and sustainable forest management.

Keywords: *Deforestation, environmental, CLASlite, adaptation, conservation.*

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SPECIES COMPOSITION AND STAND STRUCTURE OF THE PRIMARY AND SECONDARY MOIST EVERGREEN FORESTS IN THE TANINTHARYI NATURAL RESERVE (TNR) BUFFER ZONE, MYANMAR

Idd Idd Shwe Zin* and Ralph Mitlöhner

The habitat structure and floristic composition examined in this study are of great importance not only in providing a scientific baseline of information for developing a biodiversity database but also in supporting crucial information for the management decision-making process of the buffer zone areas. The main objective of this study is to examine the current status of species composition, species diversity and stand structure of moist evergreen forests distributed in the Tanintharyi Nature Reserve (TNR) buffer zone. Forest inventory was conducted in the primary moist evergreen forest (1 ha) and secondary moist evergreen forest (1 ha). In the TNR buffer zone, 83 species belonging to 31 families in the primary moist evergreen forest and 86 species belonging to 32 families in the secondary moist evergreen forest were found. The most dominant families in the primary moist evergreen forest were Dipterocarpaceae, Sapindaceae, Meliaceae, Myrtaceae, and Myristicaceae; at species level, this forest was composed of *Nephelium lappaceum*, *Myristica malabarica*, *Nephelium laurium*, *Aglaia andamanica*, and *Diospyros peregrine*. The most dominant families in the secondary moist evergreen forest were Myrtaceae, Sapindaceae, Euphorbiaceae, Myristicaceae, and Lauraceae, while *Nephelium lappaceum*, *Syzygium claviflorum*, *Syzygium sp-1*, *Eugenia oplate*, and *Myristica angustifolia* were the most

dominant at the species level. The results of Sørensen's similarity index based on common species (Ks) and the similarity index based on species dominance (Kd) were observed at about 55% and 75% between the primary and secondary moist evergreen forests. The basal area (51.39 m²ha⁻¹) of the primary moist evergreen forest was higher than that (44.50 m²ha⁻¹) of the secondary moist evergreen forest. Between these two forest types, the Shannon-Wiener, the Simpson and the Evenness indices were not significantly different at ($p < 0.05$). Mean tree density (n/ha) of the primary and secondary moist evergreen forests were 910 (± 184) and 991 (± 183).

Keywords: *Tree density, basal area, floristic similarity, floristic composition, moist evergreen forest.*

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LAND COVER CHANGE IN THE ÑEMBY HILL IN THE YEARS 1994, 2004 AND 2017

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The hereby investigation was located in the Ñemby Hill, in the district of Ñemby, Central Department, Paraguay. The general objective was to determine the land cover change in the Ñemby Hill in 1994, 2004 and 2017 for which orthophotomap was analyzed for the year 1994 and satellite images for the years 2004 and 2017. The change in land cover that is due to its variation in the years previously mentioned, was measured in hectares and classified according to the cover type in 5 categories: areas with forest cover, ground areas without coverage, water body, infrastructure and pasture. An image analysis was performed based on objects with the consequent generation of final maps through the use of the software eCognition and Arc Gis 10.4.1. Surveys to key and qualified informants were also applied in order to obtain information from their perspective about the changes in the Ñemby Hill. Finally, the arboreal vegetation on the place was examined in order to obtain information on the characteristics of the ecosystem. The data analysis allowed to conclude that there was a change in the landscape matrix in the studied area as a result of its exploitation as a quarry. Forest covered areas decreased 10% during the studied period (equal to 5,42 hectares); a result that coincided with the informants' perception, who assured that the forest covered area were the most damaged. The field studies showed that the species with the most individuals present in the area is the *Piptadenia rigida*, characteristic of degraded areas. The Ñemby Hill deserves to be protected and preserved for its symbolic, natural and cultural value.

Keywords: *Image analysis based on objects.*

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KHAT IN THE SOCIO-ECOLOGIC LANDSCAPES OF ETHIOPIA

Gessesse Dessie*

Khat (*Catha edulis*) is an evergreen shrub cultivated as a bush or small tree mainly grown in east Africa and the Middle East. Its fresh leaves and twigs are chewed or, less frequently, dried and consumed as tea, to achieve a state of euphoria and stimulation. Ethiopia is one of the major producers and exporter of khat. Khat is grown in all regions but with marked variation in respect to biophysical settings, food ecology, socioeconomic conditions, gender relations, farmers' decision-making strategies and food-security status. Khat has expanded rapidly in Ethiopia in

terms of land area used for its production at forest frontiers, in isolated forest patches and within farmland. The expansion influences forest decline directly by conversion, and indirectly through increased human activity in proximity to forests. Khat production may create tension, resulting from a conflict in interest between sustaining the native forests, with subsequent environmental benefits for the larger social group, and the economically driven choice land use made by khat farmers. Khat has undesirable health and social effect to the chewers, but the producers have important economic benefit cultivating it. In some European and North American countries khat is an illegal drug. The Ethiopia government does not approve khat consumption, but they do not discourage its production either. The contribution of khat to the national economy, its impact on the landscape dynamics and its importance to livelihood of producers are undeniable. This paper addresses the impact of khat on the socio-ecologic landscapes of Ethiopia.

Keywords: *Khat, forest, Ethiopia, drug, livelihood.*

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PREY LONG ECONOMIC FOREST, THE SOUND OF DESTRUCTION IN CAMBODIA

Khun Bunnath* and Hout Bunnong

The recent history of Cambodia's forests has been one of constant decline. During the 1980's the country's forests were cut by both the Khmer Rouge and Vietnamese to fund their fighting. When the Vietnamese left the Kingdom in 1989, the various factions that remained enmeshed in civil conflict continued this practice. After the elections in 1993, the Royal Cambodian Government (RGC) established 36 forest concessions covering a total of 7 million hectares, almost 70% of Cambodia's forest-cover (National Forest Program 2010-2029). During this period, weak law enforcement allowed illegal logging and land grabbing to go unchecked and deforestation rose dramatically. Eventually Cambodian forest communities raised significant complaints to both the World Bank, which had promoted forest concessions, and the RGC. On January 1st, 2002, the Prime Minister issued a moratorium to on logging concessions while the Forestry Administration (FA) subsequently developed a new strategy for the management of the countries forests.

Prey Lang Forest is seriously threatened by Economic Land Concessions (ELCs), mining activities, and illegal logging and clearing, which appear to involve local and provincial authorities on at least some occasions, often with the support of the military and or companies involved in land concessions. Some ELCs are being granted illegally without following existing government legislation, conducting Environmental Impact Assessments (EIA) or consulting with local communities. These communities are losing the traditional lands and resources they rely upon to survive. Like most indigenous communities around the country, Prey Lang communities oppose ELC's in their areas and are deeply concerned about their future security. The loss of the forest is seen as nothing less than catastrophic by the majority of those interviewed for this report. They do not want to change their livelihoods by working for concessionaires due to low wages, short-term ad hoc employment, and poor working conditions. Rather than benefiting rural communities, the ELC's are expected to increase in landlessness and poverty, as they have in other areas.

Keywords: *Law enforcement, environmental impact Assessments, economic Land Concessions, illegal logging, land grabbing.*

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CATALYZE FOREST LANDSCAPE PROTECTION THROUGH DEVELOPING AND IMPLEMENTING LAND USE PLANNING IN DRC

Adeloui Hugues Akpona*

The Maringa-Lopori-Wamba (MLW) landscape is one of the poorest, least developed and most remote areas in DRC. Biodiversity conservation and sustainable livelihoods are threatened by poaching for bushmeat, poor institutional capacity, uncontrolled forest clearance and land conversion for agriculture. These threats are driven by poverty as forest dependent communities have limited livelihood alternatives and primarily rely on the forest. In the process, deforestation and forest degradation exacerbate climate change. Historically, managing these threats has been hampered by civil unrest, aggravating the already limited on-the-ground enforcement measures to protect forest resources and wildlife. MLW is divided into the following macro-zones that align with relevant intervention strategies based on data-driven and participatory processes.

The selection of the macro-zones is designed to (a) protect critical habitat for targeted species, (b) ensure landscape level connectivity among different areas of ecological significance, (c) enhance ecosystem resilience, (d) provide a means of integrating conservation and development for livelihood improvements across the landscape, (e) secure social and community buy-in through empowering local communities to engage in sustainable land use planning through participatory mapping activities that will help secure management rights to their land and (f) create areas dedicated for conservation at a scale large enough to deliver conservation impact and further landscape level conservation.

AWF's hypothesis is that catalyzing forest protection through land use planning, diversifying agriculture practices and community livelihoods, and conducting skills-training and organizational capacity-building will build resilience among vulnerable communities. Building on past and ongoing activities, AWF's goal is to maintain the positive impacts by building local people's resilience around community forests while providing enough skills to inhabitants of Djolu and Befale territories to keep the forests of the landscape intact and healthy. Conducting this process raised lessons learnt and best practices to enhance future similar interventions.

Keywords: *Landscape, land use planning, forest protection.*

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Topic 2

**TOOLS, METHODS AND APPROACHES
ORIENTED TOWARDS SOLUTIONS**

S 2.1

Forest biodiversity indicators and monitoring

Chairs: Anna Barbati and Frédéric Gosselin

MULTISCALE SOCIO-ECOLOGICAL NETWORKS IN THE AGE OF INFORMATION

Maxime Lenormand* and Sandra Luque

Interactions between people and natural spaces, through leisure or tourism activities, form a complex socio-ecological spatial network changing over time and space in response to economic, social, political and cultural drivers. In the age of information, the increasing availability of large databases generated by the use of geolocated information and communication technologies (ICT) devices allow us to gain a better understanding of complex socio-ecological interactions at an unprecedented spatio-temporal resolution. Within this context, we propose to model and analyze interactions between humans and natural areas based on information extracted from geotagged photographs embedded into a multiscale socio-ecological network. We apply this approach on 16 case study sites in Europe relying on a Flickr database containing hundreds of thousands of validated and classified geotagged photographs. After evaluating the representativeness of the network, we investigate the impact of visitors' origin on the distribution of socio-ecological interactions at different scales. At a global scale first, clustering the sites according to a spatial measure of attractiveness, we detect four groups of sites. Then, at a local scale, we investigate how the distance traveled by the users to reach a site affects the way these users interact with this site in space, time and landscape diversity. The approach developed here, integrating ICT data in a network-based framework, offers a new way of visualizing and modeling interactions between humans and natural areas for the development of efficient ecosystems conservation and protection planning strategies.

Keywords: *Socio-ecological interactions, Spatial Network.*

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BIODIVERSITY INDICATORS AS INTERFACES BETWEEN ECOLOGICAL RESEARCH AND ENVIRONMENTAL MANAGEMENT: HINTS ON SOME KEY PROPERTIES

Frédéric Gosselin*, Marion Gosselin, Christophe Bouget and Ugoline Godeau

Biodiversity indicators are tools that are more and more used to formalize and concentrate the information we wish to share on biodiversity. We here wish to highlight some properties of indicators that arise from their place at the boundary between the academic and management worlds. We illustrate these properties by recent research specifically referring to Driver, Pressure and Response indicators within the DPSIR framework applied to forest biodiversity.

First, especially from a management point of view, we think we should distinguish indicators according to the magnitude of their relationship with biodiversity – and not only according to the statistical significance of the relationship. Second, due to logical and ecological reasons, we need to take into account the fact that the relationship between the indicator and biodiversity might vary in space, time or according to ecological conditions. This in particular relates to the notion of domain of validity of the indicator. Third, we need to include the possibility that the relationship be non-linear rather than linear, with especially the possibility to estimate thresholds in the relationship. Fourth and finally, we need to better apprehend which parts of biodiversity are or are not related to the indicator.

These different pieces of advice would help documenting the “identity card” of indicators in their relationship to biodiversity, by better documenting the parts of biodiversity related to the indicator under different conditions, and those that are unrelated to the indicator. This should help enhance indicators as a boundary object between research and management.

Keywords: *Biodiversity indicator; pressure; response; interface.*

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LANDOPT – AN INTERFACE BETWEEN FOREST MODEL SIMULATIONS AND OPTIMIZATION TOOLS FOR TRADE-OFF ANALYSIS AT LANDSCAPE SCALE

João H. N. Palma* and Jordi Garcia-Gonzalo

The identification, design, selection and implementation of supported measures in forest management requires a sound knowledge base as well as tools to support the forest manager in decision making. Although numerous attempts to develop decision support tools that include optimization procedures have been made, the uptake of such tools have been limited when it comes to practice, hampering the efficiency of resources use allocated to forest at a broad scale, while competing with agricultural land use under a context of global sustainable intensification.

With the purpose of spreading the use or development of self-made decision support tools, as opposite to the development of complete suites, often complex, of forest management optimization tools, we propose here in this paper to deliver an intermediate tool, so called LandOpt, that facilitates the interaction between tabular data and a solver. The tool produces a mathematical problem, in a human readable format (LP format), depending on the goals and constraints of the land manager (or any decision maker) ready to be solved by available free or commercial software. LandOpt is divided in two modules which are independent to each other, but they are sequential. One module processes tabular data into a consistent tabular format and, a second module processes the resulting tabular data into a 1) mathematical model, that is 2) sent to a solver where the results (solution) is collected and simplified to the user.

An example of using LandOpt is here presented where a forest harvest scheduling plan is explored. In this example, the solution is the best harvest schedule for each stand during a determined planning horizon.

The way results from the solver are processed for graphical results is independent of LandOpt. However, we present an example on how to process the tabular data as well as presenting results from the solver.

Keywords: *Management, planning, ecosystem services, regulation, mathematical modelling.*

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ARAUCARIA ANGUSTIFOLIA (BERTOL.) KUNTZE: COMPARISON OF TWO MODELS OF SPECIES DISTRIBUTION

Micaela Medina*, Maria Rosa Derguy, Magali Pérez Flores,
Maia Carisa Plaza Bher and Marcelo Fabian Arturi

In Atlantic Forest the majority of plantations are monocultures of exotic species. However, a native species (*Araucaria angustifolia*) is also planted for timber production. Many typical species of Atlantic Forest were found in mature araucaria plantations. Therefore, this species might be planted with shared objectives of timber production and biodiversity conservation. In order to predict available areas to establish *Araucaria* plantations in Atlantic Forest, we compared two models of species distribution with MaxEnt 3.3.3 software package. In both we used current locations of this species but different climate variables: in WC1.4 model we used WorldClim 1.4 while in WC2.0 model we used WorldClim 2.0. To validate the models we observed the area under the curve (AUC) of Receiver Operating Characteristic. AUC was 0.936 and 0.913 for WC1.4 and WC2.0 respectively, showing that both models are good. However, the variables that contributed more to the model gain were different: in WC1.4 they were temperature of the coldest month and precipitation of the driest quarter while in WC2.0 were maximum temperature of warmest month and mean temperature of driest quarter. Although both models predicted a larger area than the natural distribution of *Araucaria*, WC2.0 predicted a larger area in northeastern-center Rio Grande Do Sul State (Brazil) as well as in northern-center Misiones (Argentina). WorldClim 2.0 constitutes an improved version it is expected it to perform better vegetation models than WorldClim 1.4. Since WC2.0 predicted a larger area overlapping the ecological corridor in Misiones Green Corridor, we consider necessary to promote physiological, economic and social studies in order to evaluate the feasibility of increasing *Araucaria* plantations.

Keywords: *Araucaria*, *Maxent*, *Misiones*, *plantation*.

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BIODIVERSITY VALUES OF BRAZILIAN NATIVE VEGETATION – HOW MUCH IS PROTECTED BY THE FOREST ACT?

Flavio Freitas*

Human-induced land use change (LUC) is the most important driver of biodiversity loss. In Brazil, this process is particularly concerning considering that here are the most extensive tracts of tropical forest and other rare habitat types which host unique biodiversity. The preservation of much of this area is highly dependent on the implementation of the Forest Act, the central legal framework regulating the conservation of native vegetation on private land in Brazil.

Recent studies provide a modelling framework for assessing the impacts of the Forest Act on the protection of native vegetation and associated carbon stocks for the entire Brazilian territory. However, there is not sufficient knowledge on the efficiency of this legislation in protecting areas of high and unique biodiversity in Brazil.

In this study we apply the land use governance assessment (LUGA) model to quantify the extent to which the Forest Act protects biodiversity. For this purpose, we construct indicators at fine-scale levels to capture the multiple dimensions of biodiversity (species richness, genetic, and functional diversity) and how these are related to the native vegetation. Using state-of-the-art databases of species distribution data, GIS-based modeling frameworks are developed and

adapted to identify values of native vegetation related to the preservation of biodiversity in general, and endangered species in particular, and ecological connectivity. The results are evaluated for Brazilian regions where the LUC pressure is recognized to be most significant. The final model output consists of geoexplicit indicators at a high resolution, which informs about the degree of biodiversity protection provided by the Forest Act.

The information provided by this project can support decision-making related to the selection of areas of high importance for biodiversity protection at local and regional levels. Further, it can potentially contribute to efficient use of resources and improved effectiveness of incentive mechanisms in promoting conservation of unprotected native vegetation of high biodiversity value.

Keywords: *Biodiversity, Brazil, Forest Act, Land use Change, Deforestation, Biodiversity loss.*

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MODELLING BRYOPHYTE BIODIVERSITY PATTERNS IN A HIGHLY MANAGED LANDSCAPE WITH LIDAR DERIVED INDICES

Maurane Bourgouin*

Re-establishment of bryophyte diversity in old growth forests after silvicultural disturbances depends on the return of initial micro-habitat and microclimate conditions. However without a source of propagules (reproduction structures) within the managed landscape even perfect habitat conditions will not be sufficient to ensure bryophyte diversity. To identify these sources and therefore ensure their protection, we used LiDAR derived indices as proxies in a predictive biodiversity mapping project. Field work was carried out in the highly managed district of Black Brook in New Brunswick, Canada. Bryophytes were sampled regardless on all substrates in 45 mature and old growth managed and unmanaged forest. Preliminary results had showed only 50% shared species between managed and unmanaged deciduous stands. Species only found in unmanaged deciduous stand are mostly epiphytic species and/or liverworts indicating a more stable micro-climate and micro-habitat is those stands. Principal coordinate analysis (PCoA) will be used to highlight the main compositional patterns in stands. Using 70% of the data, regression trees using the LiDAR derived indices such as humidity index, aspect, topographic position, stand density, dead wood volume and angular canopy openness will be used to predict site diversity. Humidity index is expected to be the main driver of diversity followed by aspect and canopy openness. Predictive maps will be then tested using the reserved 30% of the data. The resulting predictive map will help achieve the bryophyte biodiversity goal in the highly managed landscape by identifying potential propagules sources.

Keywords: *Bryophyte biodiversity, predictive mapping, LiDAR, silvicultural disturbance, regression trees.*

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ASSESSING GENETIC DEGRADATION RISK ACROSS FOREST TREE SPECIES: A NATIONAL, SPATIALLY EXPLICIT BIODIVERSITY INDICATOR

Kevin M. Potter*

Genetic diversity is essential for forest tree species because it provides a basis for adaptation and resilience to environmental stress and change. The loss of the option value conveyed by genetic variation could be particularly detrimental to the future survival of tree species in the face of numerous severe stresses. The fundamental importance of genetic variation is recognized by its incorporation in the Montréal Process, which the United States Forest Service uses as a forest sustainability assessment framework. One Montréal Process indicator for the conservation of biological diversity is the “Number and Geographic Distribution of Forest-Associated Species at Risk of Losing Genetic Variation and Locally Adapted Genotypes.” This indicator has been difficult to address in a systematic fashion, however. We leverage two broad-scale datasets to assess this indicator: (1) species occurrence data from the nationally systematic Forest Inventory and Analysis (FIA) plot network and (2) climatically and edaphically defined provisional seed zones, which encompass geographic areas with similar geology, climate, vegetation, soils and hydrology. Specifically, we intersect the FIA data with the provisional seed zones, which are used as proxies for among-population adaptive variation under the assumption that adaptive genetic variation within species is associated with the kind of environmental conditions that define the seed zones. We then determine, for each species, the ratio of mature trees to saplings within each seed zone as an indicator of insufficient regeneration that could lead to the loss of genetic variation. The results offer insights into which species and which areas of the country may be experiencing degradation of genetic diversity. Such erosion of genetic variation makes species less able to adapt to environmental change, increases the risk of extinction, and lowers the overall resilience of forest ecosystems.

Keywords: *Biodiversity assessment, Montreal Process Criteria and Indicators, genetic diversity, sustainability, regeneration.*

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S 2.2

Monitoring forest biodiversity using remote sensing

Chairs: Jean Baptiste Feret and Maria J. Santos

HOW TO CAPTURE THE MEDITERRANEAN FORESTED LANDSCAPE COMPLEXITY USING REMOTE-SENSING TOOLS

Samuel Alleaume*, M. Lang, J. B. Féret, I. Diouf and S. Luque

The Mediterranean forests have been used for millennia and are organized according to a heterogeneous and complex landscape particularly beneficial to biological diversity. The forests have been degraded by overgrazing and exploitation for firewood, but also as a result of fires. Such forest areas may become open, secondary forests with several understories, but if not properly managed they may turn into varied types of high or low matorral (dry shrubland) or in some areas to heathlands that could be degraded into sparsely vegetated areas. As a result, there is an urgent need for monitoring tools to inform changes in this valuable ecosystem to support public policies to protect a sustainable management of these biodiversity hotspots. In the framework of the Essential Biodiversity Variables (EBV) developed by the GEO-BON, six classes of variables have been defined to cover different key indicators, including ecosystem structure, which is intimately linked to the fauna and flora richness. Remotely-sensed earth observation (RS) has become essential to provide a rapid, repeated and synoptic access of these EBVs (i.e., RS-enabled EBVs): the increasing availability of open access satellite data provides enhanced possibilities to monitor this natural landscape under increasing anthropic pressures. Mediterranean ecosystem could be monitor with various types of sensors, providing information on key indicators like structure, function and composition at frequent revisit times and high to very high spatial resolution. The support of innovative descriptors involving tools such as light sensors embedded on drones, spectro-radiometers or terrestrial Lidar are also needed.

Keywords: *Remote sensing structure mediterranean forest.*

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MAPPING CHANGES OF FOREST ECOSYSTEM SERVICES IN THE CONDITIONS OF FOREST DISTURBANCES AND THE AFFORESTATION OF ABANDONED AGRICULTURAL LAND USING REMOTELY SENSED IMAGES

Urmas Peterson* and Jaan Liira

Intensification of forestry and abandonment of agriculture are the processes that modify patterns in forested landscapes and ecosystem services of forest ecosystems. Forested areas are under anthropogenic pressures of creating (temporary) openings mostly by logging, but in places also by natural agents. The process of forest augmentation is accompanied by creating new edges in intact forests. Simultaneous occurs the expansion of forest into formerly non-forested land that has previously been mostly in agricultural use. Detection and proper location of both types of edges: newly created edges and expanding edges is a major challenge to forest scientists and forest mappers.

In this presentation we discuss the consequences of continuing traditional decisions and application of new management decisions that have shaped the pattern of forested landscapes. The example landscapes are presented from a variety of sites differing in their geographic latitude and located from the ecotone area of forests with tundra in the North to the area of the limit of the

forest biome in the South. We highlight a methodological approach of remote sensing based mapping of forest patches and forest disturbances using multi-temporal winter imagery, obtained both from medium resolution and from high resolution satellite images. Broad-scale patterns of forested landscape change are examined on regional and local levels, fine-scale patterns of change are examined on forest to non-forest edge level. Sustainability of forest landscapes with different patterns of patches in providing ecosystem services under different regimes of continuing pressure is estimated.

Keywords: *Afforestation, forest disturbance, landscape change.*

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UPGRADE OF 2007 CHAQUENIAN NATIVE FOREST MAP OF THE NORTHEAST SANTA FE PROVINCE. FOREST COVER LOSS 2007–2017 PERIOD

Andrés Bortoluzzi* and Hugo Zerda

The southern limit of the Chaco region extends in four departments of the northeast of the province of Santa Fe, being its natural landscape conformed by a mosaic of forests, alternating with gramineous openings, savannas and “esteros”. Like the rest of the natural ecosystems of the region, this coverage has been transformed both by its direct exploitation and by its conversion through the construction of roads, urban areas or for agricultural activities. Required by the National Law 26.331, the province of Santa Fe carried out in 2007 an inventory of the surface and distribution of native forests. From that moment and in spite of the prohibition of clearing the forests continued to be transformed. In this context, we worked with images from July 2017 of the Landsat 8 OLI satellite to estimate the surface and distribution of native forests and also to characterize and quantify the changes from forest to non-forest for the period 2007-2017 at departmental level. The estimated areas of native forest for July 2017 for the General Obligado, Vera, San Justo and San Javier departments were 198,300 ha, 530,300 ha, 59,300 ha and 79,900 ha respectively. On the other hand, the estimated forest cover loosed for the same departments were 6,700 ha, 8,200 ha, 4,400 ha and 2,600 ha respectively. These values refer only to transformations due to the clearance of tree cover and exclude changes in the structure and composition of forests due to selective logging, clearing of paths, livestock activities, which were not quantified by the processing of the satellite information proposed here. These processes of degradation were recorded in visits to the territory and to evaluate their impact, the next work stage requires remote sensing data processing together with field surveys.

Keywords: *Chaquenan forest, deforestation, remote sensing.*

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USING REMOTE SENSING AND ECOLOGICAL DATA TO DETERMINE PRIORITY AREAS FOR CONSERVATION

Ana Paola Salas Gomes, Eliana Cardoso-Leite* and Roberta De Oliveira Aversa Valente

Forest patches at urban and rural areas, have a major role in biodiversity maintenance into the cities and for the landscape. They are constantly threatened by urbanization and cropland expansion. Thus, there are many methods aiming to evaluate and understand them in order to assure their maintenance. Although, the main challenge for those methods is to find a dynamic and effective way to study those areas, to develop conservation strategies. Here, in order to fill this gap, we propose an index (LPI), to determine the forest patches condition and to determine the priority ones for the biodiversity conservation process. Firstly, based on high resolution remote sensing image, we mapped all the 158 forest patches bigger than five hectares, contained at the city of Boituva – São Paulo, Brazil. Secondly, we applied the IPP for those forest patches, the index was composed by Traditional Landscape Ecology metrics (fragment level), statistically uncorrelated among them. The metrics were evaluated in order to define their importance for compose the index, and thus, we developed an IPP index for each forest remnant. The chosen metrics were “AREA”; “SHAPE” and “CONNECTIVITY”, (Euclidean Nearest Neighbor Distance). After that, the forest patches were grouped based on their IPP value in priority classes (low, medium and, high). As a further step, into those priority forest patches, we aim to apply a BII (Biotic Integrity Index) wich is based on rapid ecological assessment. Through the correlation analysis between the LPI and the BBI analysis, we will evaluate the relation between the conservation level in the field, and the priority level attributed by IPP. Hence, we aim to determine the relationship between the traditional landscape metrics, using the IPP, and the current biological (BBI) conservation level of the forest patches in the field, to indicate priority areas for conservation.

Keywords: *Protected areas, biotic integrity index, landscape priority index, urban planning.*

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A MULTITEMPORAL ANALYSIS OF THE CHANGE IN THE NATIVE FOREST COVERAGE IN PARAGUARÍ IN THE PERIODS OF 1990, 1995, 2000, 2005, 2010, 2015

Fiorella Ricardi*

An analysis of land cover, based in the normalized difference vegetation index (NDVI) was conducted in Paraguarí, Paraguay. Considering that Paraguarí presents high rates of deforestation and degradation in native forests. The mean reason was to analyze the change in the native forest coverage in Paraguarí in the periods of 1990, 1995, 2000, 2005, 2010, 2015. In order to carry out this project, LANDSAT 5 and LANDSAT 8 OLI products were used, combining remote sensing technics and forest field inventories (Hirata 2014).

On the one hand, in scene 225078 were obtained, for forest cover in 1990, 32.29% of the total extension of the area, and in 2015, the area included 12.71% of this land use. Considering the different pressures exerted on the forest cover to the area, generating continuous degradation of forest resources, losses represent 19.58% of the total area under study.

On the other hand, in scene 226078 the results obtained from forest cover in 1990 are 21.49% of the total extension, meanwhile, in 2015 there was a loss of 0.07% in the study area of forest cover. Which evidenced the lost of 16.19 % of the area of the forest coverage in the scene 225078. Also the lost of 2.68 % in the area of the forest coverage in the scene 226078.

Keywords: *Change in land use, forest cover, satellite images.*

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DISTRIBUTION OF TEAK FOREST RESILIENCE PATTERN IN EDUCATION AND TRAINING FOREST OF UNIVERSITAS GADJAH MADA AT GETAS NGANDONG

Jon Piter Zai* and Emma Soraya

Education and Training Forest of Universitas Gadjah Mada (UGM) at Getas Ngandong is a Special Designation Forest Area (KHDTK) established since 2016. KHDTK UGM Getas Ngandong requires a lot of information for forest management planning including land cover changes. This information is needed to anticipate the impact of loss due to management and/or possible disturbances. Analysis of land cover changes can be modeled in the form of forest resilience. Forest resilience is the ability and capacity of the system to absorb or withstand interventions. The objectives of this research are: 1) to quantify and map the distribution of teak forest resilience pattern of KHDTK UGM based on land cover changes in 1994-2017; and 2) to identify the characteristics of resilience pattern in the research area.

This research was conducted in 5 RPH of 5345,85 Ha from total 9 RPH in KHDTK UGM using Object Based, Overlay, and Qualitative GIS method. The Object Based method was used to interpret and classify land cover from satellite imageries. Overlay method was used to model the pattern of land cover change. The Qualitative GIS method was used to identify the characteristics of teak forest resilience pattern in the research area.

The results shows that the research area has 13 patterns of land cover changes from 1994 to 2017. Seven patterns are teak forests that resilient as large as 3124.04 Ha (58.43% of the total area of research) and the rest experience shifting. The characteristics of teak forest resilience pattern are divided into 5 models where there are 3 models undergoing imperfect resilience, 1 model undergoes a perfect resilience and 1 model undergoes shifting.

Keywords: *Landsat imagery, object based, overlay, qualitative GIS, land cover change.*

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TOWARD AUTOMATED ESTIMATION OF VEGETATION COVER IN DIFFERENT STRATA USING UNMANNED AERIAL VEHICLES (UAVs)

S. Torrella*, F. Gómez-Fernández, D. Acevedo, R. Ginzburg,
P. Arriaga-Velazco and P. De Cristóforis

In the last years UAV imagery has bridged the gap between intensive (but sparse and reduced in area) fieldwork in plots, and extensive (but undetailed) data acquisition from satellite images to carry out forest inventories and research. This disruptive technology has allowed significant advances in gap detection, species identification, estimation of trees height and other structural parameters, among others issues. Thanks to open-source software publicly available online, obtaining three dimensional geographic data from UAVs imagery, such as orthomosaics, height-maps, 3D meshes and pointclouds, can be easily done. However, the procedures to estimate forest structural parameters using these data are still inaccessible to most of the forest technicians and researchers who are not familiarized with image processing and computer vision techniques.

In this work we present a methodology that makes use of the digital terrain data gathered from UAVs to parametrize the heightmaps in order to segment regions according to vegetation cover. We developed the study in the Argentine Chaco, where the management of forest resources are a key issue. In the east of Formosa Province, this methodology allowed us to clearly distinguish palm savanna and forest areas. Also, users can retrieve forest canopy height and classify data into different forest types.

This methodology has many applications on the study of forest, and other natural vegetation covers. For example, assist in the elaboration of vegetation maps, forest inventories, timber extraction monitoring, etc.

Our final goal is to get an open-source tool publicly available online, that will allow forest technicians and researchers, but specially national and provincial authorities responsible of the management of forest resources, to improve their abilities to use UAV imagery and processed three dimensional geographic data.

Keywords: *UAVs, remote sensing, forest mapping.*

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LOOKING BACK TO MOVE FORWARD: ANALYZING IMAGERY TO UNDERSTAND ENVIRONMENTAL CHANGE AND COMMUNICATE OPERATIONAL OPTIONS

David Colville*

Remotely sensed imagery provides extremely valuable input for understanding our changing environmental landscapes. Image collection and processing techniques are continuously improving, as are the opportunities to better utilize historic image acquisitions. This presentation focuses on two initiatives in Southwest Nova Scotia, Canada that exemplify this, the Southwest Nova Biosphere Reserve Landscape Connectivity Project and the Cornwallis River Watershed Landscape Change Project.

The Southwest Nova Biosphere Reserve (SNBR), one of Canada's largest biosphere reserves (1,546,374 ha), has at its core, the Kejimikujik National Park and National Historic Site and the Tobeatic Wilderness Reserve. These protected areas are predominantly surrounded by forested working lands. Parks Canada monitors the ecological integrity of these forest ecosystems using a set of landscape measures. These measures focus on the habitat amounts and the habitat connectivity of five focal species groups in the Park, in the Greater Park Ecosystem, and in the SNBR. Decades of aerial photography and satellite imagery have fueled these analyses. The results effectively illustrate the landscape impacts on the selected focal species.

The Cornwallis (or Jijuktu'kwejk, its first nations name) River Watershed is one of the most degraded in Nova Scotia, and under increasing pressure from irrigation, peat mining, grazing, effluents, and other land-use practices. The river was very important to first nations and early colonial settlers hundreds of years ago. Today very little natural forest cover remains. Aerial photography collected in 1931 reveals a glimpse into the watershed conditions of the past. Hundreds of photos have been mosaicked together to provide the NS government, community groups, and local first nations with information key to understanding watershed health and landscape-level ecosystem integrity. The mosaic has been classified and spatially fused with current land cover mapping to assess changes to river geometry and land cover, help identify restoration opportunities, and inform habitat management.

Keywords: *Historic imagery, landscape change, habitat analysis, ecological integrity.*

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OBJECT-ORIENTED IMAGE SEGMENTATION AND CLASSIFICATION OF A SITE WITH FORESTS OF ARAUCARIAS

Janet Villalba Marín*, Paulo Costa de Oliveira Filho and Thales Sehn Korting

This article aims to test the effectiveness of the technique Object – based image analysis (OBIA), using the data mining algorithms provided by GeoDMA system. The area of study corresponds to the Irati's FLONA Brazil, whose main vegetation type corresponds to the native forests of Araucaria (*Araucaria angustifolia*). Lately, separating and extracting information related to Araucaria is a challenge in the natural distribution of this species. On the other hand, high resolution satellite imagery can be used to map such target. There are several experiments in the literature which aim to classify Araucaria, but very few are based on OBIA techniques using free software. The test image was obtained by the Ikonos satellite, with 4 bands of 8 bits, and clipping area with 459 x 653 pixels. The segmenter based on Baatz & Shape (2000) was used, and subsequently computed all the features from the regions (781 polygons), then training samples were taken from 5 classes (Araucaria, Broadleaves, Soil, Shadow and Herbaceous). Once collected all the samples, we proceeded the classification using the decision tree algorithm. It was observed the main attributes that helped to model the classes, mainly the ones related to ratio, mode and dissimilarity. Using this model we obtained good results in the image classification

(Kappa value of 0.89). It was concluded that this technique obtained good accuracy, yielding results quickly and easily interpretable by domain experts.

Keywords: *OBIA, data mining, GeoDMA, forests of araucaria.*

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FOREST VOLUME-TO-ABOVEGROUND TREE BIOMASS MODELS FOR THE SECONDARY FOREST IN IITA, IBADAN, NIGERIA

Ehimwenma Victor Aghimien*

It is generally agreed that preservation of forest areas can contribute strongly to the mitigation of global climate change. However, studies have demonstrated that there are still uncertainties for an accurate estimation of carbon stocks. This study is aimed at developing allometric equations for the estimation of above-ground tree biomass (AGTB).

Ten sample plots of 20m x 20m were randomly laid. Diameter at Breast Height (DBH), Total Height (TH), Crown Diameter (CD) and Wood Density (WD) were measured. Forty quadrants of 1m x 1m for litter fall collection were randomly laid in four locations within the plots. Ten trees with DBH closest to the mean diameter were selected for destructive sampling. Biomass of the plots mean tree were pooled together to developed allometric equations to obtain biomass. Data were analysed using descriptive statistics and regression analysis.

A total of 947 individual species were identified, belonging to 16 families. Allometric equations of family level and whole stand level for estimating AGTB were developed. The best fitted allometric equations were used to predict AGTB. Model 3: $\ln(\text{AGTB}) = c + \alpha \ln(\text{DBH}) + \beta \ln(\text{THT})$ and Model 8: $\ln(\text{AGTB}) = c + \alpha \ln(\text{DBH}) + \beta \ln(\text{avgWD})$ were indicated the highest modelling efficiency with an R² value of 0.984, 0.948. Model 3 and 8 were selected as the best model for predicting the AGTB with an estimation of 17698.76g and 838036.15g at family and whole stand levels. Allometric equations of whole stand level for AGTB indicated good correlation with THT, DBH, CD and WD (0.534, 0.597, 0.751, and 0.648). Therefore, carbon capture per hectare of AGTB was 368280.40g/ha. Carbon capture per hectare for litter had 2663.259g/ha using standard method.

Model 3: $\ln(\text{AGTB}) = c + \alpha \ln(\text{DBH}) + \beta \ln(\text{THT})$ and model 8: $\ln(\text{AGTB}) = c + \alpha \ln(\text{DBH}) + \beta \ln(\text{avgWD})$ were most suitable for estimating AGTB.

Keywords: *Secondary forest, biomass, allometric equations, carbon, model.*

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OP 2.3

Connectivity and landscape patterns in human dominated landscape

Chair: Kalev Sepp

A COMPOSITE GRAPH THEORETIC MODELING FOR LANDSCAPE CONNECTIVITY TO INFORM GOVERNMENT POLICY OF BIODIVERSITY CONSERVATION

Mohammed Shariful Islam* and Michael Shannon Quinn

Computer aided modeling, with its capability to produce necessary details of analytics, has become popular to inform the preparation of government policy for biodiversity conservation. Computer simulation has proven effectiveness to deal with ecosystem fragmentation happening for increasing anthropogenic activities, especially in natural areas beyond the cities. So, to manage the ecosystem fragmentation, landscape connectivity studies can substantially advocate government policy making to ensure long term ecological integrity. One measure of landscape connectivity is the degree to which landscapes are connected among resource patches. Connectivity among the resource patches that provide the wildlife with core habitat is essential to their survival but highways and other anthropogenic developments commonly impede wildlife movement. The purpose of this study was to identify suitable locations for highway crossing structures for wildlife movement. With this aim, the functional connectivity that the wildlife maintains was modeled using human footprint data over a regional landscape in western Canada. A graph-theoretic approach was employed to identify corridors, linkage zones, and the locations where they cross the highways. Betweenness centrality model was used to compute shortest path, current flow and network flow of movement across landscape lattices. As a result, shortest paths identified a set of geodesic paths to connect the resource patches, current flow identified a number of movement zones around the resource patches, and network flow identified linkage zones in the network. Finally, the composite of the outputs was used to identify suitable locations for highway crossing for maintaining wildlife movement on the landscape. This study demonstrates a specific policy action that is produced from computer aided simulation and explores a number of policy aspects including land-use decision making that can effectively be informed by computer aided modeling to better manage human-environment interaction without fragmenting the ecosystems.

Keywords: *Conservation policy, landscape connectivity, spatial modeling, graph theory, highway crossing.*

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FOREST COVER CONNECTIVITY AND FRAGMENTATION OF THE COFFEE CULTURAL LANDSCAPE OF VALLE DEL CAUCA, COLOMBIA, BETWEEN 2000 AND 2014

Jorge Rubiano*, Angela Hidrobo, Juan Carlos Sandino and César Franco

The coffee rural landscape of northern Cauca Valley in Colombia, is part of the Coffee Cultural Landscape of Colombia (CCLC), signed in 2011 by the World Heritage Committee of UNESCO. Among the many actions required for its management, it is necessary to know the structure and arrangement of its biophysical components, the changes that occur within them and how they are affecting the fragmentation and connectivity of the forest cover. This knowledge is fundamental to preserve the fauna and flora associated with this landscape and the surrounding tropical cloud forest. The purpose of this study was to analyze the changes in forest cover that occurred between

2000 and 2014, i.e., the degree of fragmentation and connectivity of the CCLC, using three data sources of different resolution and origin to identify the most appropriate data sets for this type of study and to contribute to the organization and management of the area. Contagion metrics, morphological spatial patterns and multiscale analyses were calculated using GUIDOS TOOLBOX, and the probability of connectivity index (PC) was calculated using the CONEFOR application. The results indicated a reduction in the quality of the landscape and the most appropriate data sources for this type of analysis that can provide indicators to guide the management decisions of area managers.

Keywords: *Landscape metrics, land-use changes, spatial analysis, coffee production system.*

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THE POINT OF NO RETURN: LANDSCAPE TRANSFORMATION IN THE TROPICS DOES NOT NECESSARILY LEAD TO IMPROVED LIVELIHOOD OUTCOMES

Terence Sunderland*

The forest transition curve, in which forest loss, transformation and recovery mirrors economic development across nations has become a pervasive typology in understanding how environmental change can be predicted. While for some countries, the transition curve has proved to be remarkably prescient, for many tropical countries the “bottom of the curve” ultimately represents permanent transformation of the rural estate. Much of this transformation is driven by permanent agriculture such as palm oil, cattle ranching or other systems that do not facilitate the “restoration” stage of the transition.

Aside from the considerable environmental impacts of this transformation, local livelihoods are also impacted. While there are often short-term social and economic benefits to converting forests, in the longer term the positive outcomes seem increasingly uncertain. The loss of small-holder agricultural land, provisioning ecosystem services, and forest-based incomes can deleteriously affect the resilience, dietary diversity and overall well-being of those affected.

In this paper we present the results of a multi-country assessment of agrarian change patterns in the tropics with the concomitant impacts on rural livelihoods, in terms of broader ecological processes and immediate health and income impacts. We conclude that agrarian-driven changes that lead to permanent forest loss do not always result in broader economic development to those who are most affected and, in fact, can lead to increasingly negative, albeit unintended, outcomes for local communities.

Keywords: *Landscapes, livelihoods, diets, agriculture, transformation.*

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STUDY OF THE DYNAMICS OF LAND USE FOR ENVIRONMENTAL MANAGEMENT OF THE SAN MARTIN URBAN NATURAL RESEVE – STRATEGIES FOR RESTORATION AND CONSERVATION

Jimena Albornoz, Diego H. Pons* and Sofia De Souza

The city of Córdoba Capital, Argentina experienced a noticeable urban development in peripheral zones from 1990 to the present advancing on natural areas, causing its loss, fragmentation and degradation due to the lack of management plans. The spatial analysis and the identification of the causative factors are necessary for an adequate territorial ordering, the conservation of biodiversity and the ecosystemic functionality. In this context, this work had the objective of carrying out an environmental management plan to develop restoration and conservation strategies in the only protected area and last relict of native forest that exists within the urban network, the San Martin Urban Natural Reserve (RNUSM) . The study area covered an area of 49257 hectares, including forest ecosystems, reservoirs, urban areas, quarries, agricultural and natural reserves to analyze the loss of connectivity with respect to other mountain systems. Land cover changes between 1990, 2004 and 2018 were studied using Landsat 5 TM and 8 OLI images. Supervised classifications were made, identifying forests, shrublands, pastures, agricultural, urbanization and naked soils, observing an increase in urbanization and isolation of RNUSM with the Sierras Chicas corridor, and a riverbank forest connection to the Suquía River. Out of a total of 3592 ha of new urban areas registered between 1990 and 2018, 36% belong to closed neighborhoods. On the other hand, agricultural land remained between 1990 and 2004, was drastically reduced by 95.57% between 2004 and 2018, and forest were losted in 39.32%. Finally, guidelines for the design of the corridor with Sierras Chicas and management of protected natural areas for the RNUSM are discussed.

Keywords: *Forest, landscape, remote sensing, urban development.*

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ASSESSING REFORESTATIONS AND THEIR EFFECTS ON CONNECTIVITY AT THE ECOREGIONAL SCALE THROUGH THE UPDATED (2018) SPANISH RURAL LANDSCAPES MONITORING SYSTEM

Sergio González-Ávila*, César López-Leiva, Daniel C. Sánchez-Gómez,
Santiago Saura and Ramón Elena-Rosselló

In 1939 a national reforestation plan was devised in Spain, which was partially implemented in the subsequent decades. Objectives and methods of this plan have been controversial, but undoubtedly must be interpreted within the socio-economic framework of that historical moment. In any case, reforestations supposed a land use change which modified landscapes. Our goal was to analyse these changes at the landscape scale and its effects on functional forest connectivity in a Spanish ecoregion. Our hypothesis was that land use changes produced by these reforestations currently should be providing new forest habitat (ecological restoration). Using updated data from the SISPADES 2018 survey (Spanish Rural Landscapes Monitoring System), and also previous data from the 1956, 1984, 1998 and 2008 surveys, we 1) assessed the persistence of these reforestations, 2) checked if they have produced abrupt changes in the landscapes and 3) gauge their effects on forest habitat connectivity through the PC (Probability of Connectivity) and ECA (Equivalent Connected Area) indices. Regarding connectivity, our aim was not to focus on a single specific species, but rather to evaluate temporal trends of habitat availability for forest-

dwelling species in broad sense. Within the resilience framework, reforestations derived from this plan could be interpreted as a perturbation affecting landscapes. In this respect, our analyses may also build on the spatial resilience paradigm, as it is feasible to evaluate the perturbation intensity and landscapes capacity of absorption. In landscapes where major changes took place a reorganization (α) phase may have arisen, being the influence of landscape antecedent conditions and the role of connectivity key topics. Additionally, the spatio-temporal characterization of landscape structures aids in providing quantitative understanding of the range of variation in landscape structure metrics, which could be of importance for managers and their interpretation of current and planned or restored landscape structures.

Keywords: *SISPARES, landscape change, restoration, habitat availability.*

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COMPOSITION AND STRUCTURE OF HUMAN DOMINATED HABITATS IN ESTONIA AND THEIR ROLE IN SPECIES DISTRIBUTION

Diana Pungar*, Robert H. G. Bunce and Kalev Sepp

The scientific importance of the paper is to get valuable data about human dominated landscapes in order to obtain a suitable data set for modelling vegetation change. The fieldwork was carried out from 2015 to 2017. Two hundred and fifty areal and linear plots were recorded and their characteristics and frequency described. The results of the data comparison based on the fieldwork and the Atlas of the Estonian flora demonstrates the efficiency of the methodology. Four hundred and thirty three 433 species were recorded which is 24 % of all species in the country. However, as the target of the research is to emphasize on the disturbed areas, the rare species (less than 30 records in the atlas) were left out. With this selection criterion, the database involves 42 % of all common species in Estonia. The main results are: firstly, invasive species are found especially in linear elements such as roadsides and lines of trees. Furthermore, the amount of bare ground gives spare room for extra colonization for new species. Secondly, different habitats are vulnerable to robust and vigorous invasive species as *Galega orientalis*, *Bunias orientalis* and *Lupinus polyphyllus* and competitive local species such as *Filipendula ulmaria* and *Epilobium angustifolium*. Analysis of the Atlas of Estonian flora shows trends in species distribution. For example, *Lupinus polyphyllus* is mostly prevalent in Southern-Estonia, but it is spreading rapidly, causing changes in vegetation distribution in several habitats, including forests. Comparison of clear felled areas and forest habitats show obvious changes in vegetation composition. Disturbed soil makes the habitat vulnerable—new species have potential to invade and take advantages in spreading. At the same time, the number of forest species is decreasing. The research shows that the habitats, with human impact has a great role in species colonization and hence their contribution to connectivity.

Keywords: *Connectivity, disturbed habitats, climate change, common species, invasive species.*

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Topic 3

**GLOBAL CHANGE, VULNERABILITY
AND ADAPTIVE MANAGEMENT
OF FORESTED LANDSCAPES – HOW TO
MANAGE BIODIVERSITY THREATS?**

S 3.1

Changes in forest ecosystems
of South America between
global drivers and regional context

Chair: Ignacio N. Gasparri

CAN FOREST EXTRACTION, LIVESTOCK KEEPING AND TOURISM BE COMPLEMENTARY?

Juan Haridas Gowda*, Lucas Garibaldi, Matías Goldenberg and Andrea Cardozo

Most forest land in Argentina has historically been used for livestock keeping. Dense forests have been opened to stimulate the production of grass in relatively extensive management systems. Whereas in some semi-arid forests of Argentina the combination of grazing and fire used to improve pastures is still a common practice, the fire ban along the Andean forests has led to a gradual recovery of forests, and a concomitant reduction in forage production that is reflected in decreasing heads of sheep and cattle during the last four decades.

The Andean forests have also been a source of lumber for housing and furniture, as well as firewood. The buildings of the region are mostly wooden constructions, following a characteristic style that resembles of alpine landscapes. Historical lack of silviculture and forest planning, combined with promotion of establishment of conifer plantations has led to a systematic reduction in the production and management of native species with high potential

Unlike livestock keeping and forest production, tourism is a growing source of income for the region, which concentrates most of the Country's National Parks and is known for its clean lakes, snowy mountains and outdoor activities. In this presentation we explore some of the synergetic effects of combining forest and livestock management with tourism, define key issues that have hindered their development, and propose lines of research and public policies that may promote a sustainable development of the Manso valley through a multipurpose forest management.

Keywords: *Landscape planning, value addition, short term benefits.*

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NEOTROPICAL REFORESTATION HOTSPOTS: BIOPHYSICAL AND SOCIOECONOMIC TYPOLOGIES OF CONTEMPORARY FOREST EXPANSION

A. S. Nanni*, S. Sloan, M. Aide, J. Graesser, D. Edwards and H. R. Grau

Tropical reforestation is a significant component of global environmental change that is far less understood than tropical deforestation, despite having apparently increased widely in scale during recent decades. The regional contexts defining such reforestation have not been well described. They are likely to differ significantly from the geographical profiles outlined by site-specific observations that predominate in the literature. In response, this study determines the scale and defining contexts of apparently spontaneous reforestation. It delineates regional 'hotspots' of significant net reforestation across Latin America and the Caribbean and defines a typology of these hotspots with reference to the biophysical and socioeconomic characteristics that unite and distinguish amongst them. Fifteen regional hotspots were identified on the basis of spatial criteria pertaining to the area, distribution, and rate of reforestation 2001-2014, observed using a custom continental MODIS satellite land-cover classification. Collectively, these hotspots cover 11% of Latin America and the Caribbean and they include 167,667.7 km² of new forests. Comparisons with other remotely sensed estimates of reforestation indicate that these hotspots contain a significantly disproportionate share of tropical reforestation, continentally and pan-tropically. The extent of reforestation as a proportion of its hotspot was relatively invariable (3-14%) given large

disparities in hotspot areas and contexts. An ordination analysis defined a typology of five clusters, distinguished largely by their topographical roughness and related aspects of agro-ecological marginality, climate, population trends, and degree of urbanization: ‘Urban lowlands’, ‘Mountainous populated areas’, ‘Rural highlands’, ‘Rural humid lands’ and ‘Rural dry lands’. The typology highlights that a range of distinct, even oppositional regional biophysical, demographic, and agricultural contexts have equally given rise to significant, regional net reforestation, urging a concomitant diversification of forest transition science.

Keywords: *Reforestation, Latin America and the Caribbean, hotspots, regional contexts.*

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DYNAMICS OF THE LAND COVER IN THE PARAGUAYAN CHACO: A LOCAL ASSESSMENT

Romina Cardozo* and Ricardo B. Machado

The Gran Chaco is a very prominent region in South America that is experiencing high conversion due to the expansion of cattle ranches, threatening the endemic species found in the region. We analyzed the spatial-temporal land cover changes between 1995-2014, and verified whether the legislation is being complied with. We used Landsat 5 and 8 imagery to generate maps of the first and second trajectories of land cover change (1995-2005 and 2005-2014 respectively) in order to evaluate local landscape changes and their impact on public protected areas. Changes in cover almost tripled in the second trajectory, from 0.74 to 1.99, which was determined by drivers at local, regional and global scales. The landscape is connected by windbreaks, but least so in the Central Chaco, where connectivity is threatened. Moreover, we identified plots which were converted into Protected Areas, but whose boundaries were threatened by subsequent land cover changes taking place at a distance of up to 1 km, indicating that the buffer zones are not working as a prevention area. The lack of planning for landscape changes threatens landscape connectivity for biodiversity, and the lack of incentives for conservation expose the Paraguayan Chaco to the ecological consequences of land conversion in semi-arid environments.

Keywords: *Natural vegetation loss, Landsat, windbreaks, protected area, buffer zone.*

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REFORESTATION AND ADAPTIVE MANAGEMENT OF BURNT YUNGAS FORESTS

Flavio C. Speranza* and Ezequiel D. Balducci

Yungas piedmont forests in Jujuy Province, NW Argentina, are exposed to recurrent fires, resulting in intensely degraded forests with serious losses in productive and ecological functionality. This work evaluates techniques of active and passive restoration of native forests. Four pilot sites of 10 hectares each were established in properties of forest producers that were affected by fires in 2010 and 2013. Active restoration consisted in the implantation of native species with high timber value in enrichment belts of 5, 10, 15 and 20 m wide and 20 m of interbelts. Belts were mechanically and manually opened. According to belt wide, we planted one, two

or three tree rows, with a distance of 4x3 m. Species used were *Handroanthus impetiginosus* (Lapacho rosado), *Cedrela balansae* (Cedro Orán), *Cordia trichotoma* (Afata), *Tipuana tipu* (Tipa blanca), *Pterogyne nitens* (Tipa colorada) and *Enterolobium contortisiliquum* (Pacará). Passive restoration consisted in the release of lianas, shrubs and other competitors, at naturally established regeneration and re-sprouting sites with desirable silvicultural characteristics. This experience will allow evaluating different restoration strategies considering silvicultural parameters related to recovery of forestry productive. In addition, we will be able to quantify time and cost requirements of the different interventions. Results of this work, a novelty for Argentinean Yungas, will provide management information for forest producers and orientation guidelines for public policies in the region.

Keywords: *Forest enrichment, burnt forest restoration, Argentinean Yungas.*

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AGRICULTURAL POTENTIAL AS AN INDICATOR FOR 21ST CENTURY LAND USE CHANGE ACROSS SOUTH AMERICA'S ECOREGIONS

Lucía Zarbá*, H. Ricardo Grau, N. Ignacio Gasparri and Jordan Graesser

Cropland and pastureland are expanding throughout Latin America, often replacing forest ecosystems. Commodity production for export is proposed as one of the main drivers of this expansion, and indirectly these changes induce other land use changes (e.g. low profit agriculture abandonment, rural-urban migration). Previous studies found a segregated pattern of expansion and reorganization of the different land uses across the continent, suggesting that geography plays an important role in these dynamics. Foresee which ecoregions move in each direction is important for contextualizing policy and planning efforts to maximize land use efficiency. In this study, we created a map that tried to capture the agribusiness investor viewpoint as a major agent of change. Specifically, we were interested in which ecoregions are more likely to undergo similar transformation dynamics and what type of agricultural activities may occur in the different ecosystems? To address these questions we proposed a typification of agricultural potential as an indicator of the overall land use change processes expected in each ecoregion based on three attributes: (i) aptitude for mechanized agriculture, (ii) aptitude for rain-fed agriculture, and (iii) distance to consumption/distribution centers. In addition, alternative thresholds with increasing level of tolerance were explored. We grouped the ecoregions through cluster analysis, repeating the analysis for all combination of thresholds (n=48). Finally, we analyzed the sensitivity to each attribute and the correlation between the clusters and cropland cover area and its change between 2000-2014. Results as of now showed that maps with more flexible thresholds correlated better with patterns of cropland area. Correlation with cropland area showed big sensitivity to accessibility. In general, patterns cluster analyses found 4 big groups: mountain, well connected intermediate humidity and relief, flat dry isolated, and flat wet well connected ecoregions. Ecosystems in the latter are the most vulnerable to future agriculture expansion.

Keywords: *Ecoregions, land use change, cluster analysis, agricultural typification.*

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THE ROLE OF DISTAL DRIVES (TELECOUPLINGS) IN THE LAND USE CHANGE OF THE ARGENTINEAN DRY CHACO IN THE LAST DECADES

Nestor Ignaico Gasparri*

Along the last decades, the land use in the Dry Chaco has been incorporating actors and distant drivers (telecouplings) that in combination with local condition modeled the land use change in the region. This presentation tries to review the land use change in the region applying the concept of telecouplings in a description of the temporal sequence of links network of the region and how this affects the modes to solve the land use competition and the forest landscape change. Different interested sectors try to establish the links and promote the competition resolution mode more convenient for their goals. On the one hand, the agribusiness sector prioritizes the commodities trade flows and try to retain the land-use competition playing out at a local scale, with little regulation, and under market forces. On the other hand, local communities (indigenous communities and traditional small-scale farmers cattle ranchers), try to prioritize information flows to national and global actors to modify norms and rules of land use and shift the resolution to the policy action. During this process, new actors and links have emerged affecting the land use. The national government takes on the role of a mediator to resolve conflicts promoting a new legislation (new Forest Law that request forest zoning). The global community joins the land-use competition by adding alternative land uses (e.g carbon conservation) and by market mechanisms that create feedback to target the producers and their practices. A common pattern that I describe is that telecouplings related to agricultural trade promoted large forest area conversion. However, in the long run, others telecouplings may also act to partially counterbalance this transformation incorporating conservation and sustainable practices in the region.

Keywords: *Telecouplings, scaling, governance, deforestation.*

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SUSTAINABLE MANAGEMENT OF NATIVE FOREST AS A TOOL FOR CITIZENS' PARTICIPATION AS WELL AS A VEHICLE FOR DEVELOPMENT: CASE STUDY – THE PROVINCE OF CHACO

Maria Noelia Ordenavia* and Paola Gevaerd Bernal

This research paper aims at observing a particular case, at both national and provincial level, focusing specifically on the province of Chaco, mainly during the XXI century, while using it as model of sustainable development. The above-mentioned case centers on the effective use of natural resources, the dynamic interaction between forest and agriculture as well as the implementation of a public policy package to a particular sector of the economy: Forestry (more specifically native forests). The chosen sector provides the province great relevance from the economic point of view, at least from two aspects. 1) In terms of employment, this model highlights the importance of regularly employed worked force by taking also into consideration not only the current socio-economic contexts of trade openness, but also the almost non-existent dynamics in the private sector as regards employment creation. 2) In the case of the export sector, “the most important industries in this province are those related to tannin and coal, being the province the main exporter of such products by means of a mixed development strategy for this sector as well as harnessing its natural resources and the comparative advantages meanwhile it looks for and targets at a higher complexity of its production system. For the sake of its continuity,

the presence of a strong well-established provincial State is required to increase the technical skills and knowledge of and optimize those sectors that demand a high concentration of workforce as well as making them gradually less dependent. These kinds of goods are highly competitive products due to the absence of similar goods in the market and help to overcome the inconvenients derived from what we know as: structural duality” (Diamand, 1972, López, 2012, Shorr y Winer, 2014).

Keywords: *Forest, agriculture, public policy, Chaco.*

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DEFORESTATION DIVERGENCES IN TRANSBOUNDARY ECOREGIONS OF SOUTH-AMERICA

María Piquer-Rodríguez*, N. Ignacio Gasparri, Lucía Zarbá and H. Ricardo Grau

Ecoregions are homogeneous ecological entities of, often, big size that can cross national borders. Likewise, each country has its own socio-economic characteristics influencing land-use patterns that, in theory, differ within neighboring regions. Yet, global forces can operate across countries and promote the homogenization of land-use practices regardless of administrative borders. Understanding the national divergences of transboundary ecoregions and the factors that characterize them may aid at improving the natural resource planning of countries at regional scales. South-America harbors a diversity of nations and dynamic ecoregions that makes it an interesting study case. We studied the 43 transboundary ecoregions of South-America that are shared among two or more countries and have less than 90% of their area within one country. We characterized the socio-economic development and deforestation patterns of national-ecoregions (i.e., the section of a transboundary ecoregion that lies within a country) using variables of accessibility, night-time lights (as an indication of urbanization), fires (as a management tool), cropland expansion, grazing land expansion and deforestation between 2001-2014. We analyzed divergences by calculating the Euclidean distance of all the variables among pairs of national-ecoregions that shared a border. Our results show that some national-ecoregions experience similar development between national borders. This is, for example, the case of the national-ecoregion Dry Chaco Argentina-Paraguay that is less divergent (i.e., more similar) than the Dry Chaco Bolivia-Paraguay in terms of socio-economic development and deforestation patterns. Our results highlight that planning land use at regional scales should be done with care since assuming that administrative borders differ in their development trends may be an oversimplification and future deforestation pathways in neighboring countries may converge. This is of special importance in regions that share transboundary natural resources.

Keywords: *Euclidean distance, national, planning, socio-economic development.*

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CONSEQUENCES ON THE GROWTH OF FOREST SPECIES DUE TO BARK STRIPPING CAUSED BY THE INVASIVE SQUIRREL, *CALLOSCIURUS ERYTHRAEUS*, IN ARGENTINA

Paula A. Pedreira*, Eduardo Penon and Mariela Borgia

The invasion of exotic species causes diverse impacts on natural, productive ecosystems, urban services, public health and cultural identity. In particular, some mammals such as squirrels debark trees threatening to forest systems, especially in places where they are introduced. Bark stripping can damage the growth and survival of trees, with direct economic losses for the timber industry and by the costs associated with the mitigation of the damage or control of these mammals. This work was carried out in a productive forest establishment located in Luján district (Buenos Aires, Argentina). The effect of debarking on wood volume and trunk features caused by the invasive red-bellied squirrel (*Callosciurus erythraeus*) included in the list of detrimental species of Buenos Aires province, was studied. Debarking of these squirrels affected growth tissues and caused volumetric losses of wood in three species of forest importance in the region (*Pinus elliottii*, *Eucalyptus dunnii* and *Populus deltoides*). For *P. elliottii* of 8 years a 20% ($p < 0,05$) of detriment was found, for *E. dunnii* of 6 and 16 years the detriment ranged between 35-40% ($p \leq 0,01$) and 58% ($p \leq 0,01$) in *P. deltoides* of 3 years. The descope of individuals with damage was the main deformation observed in the trunk of *E. dunnii* ($p < 0,001$) and *P. deltoides* ($p < 0,001$). This information will be useful for future studies assessing the impact of this squirrel in other forest systems. Further studies are needed to propose and delineate possible management actions of the species in order to avoid its expansion into areas of high productive value or conservation.

Keywords: Red-bellied squirrel, invasive species, bark stripping, forest damage.

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DOCUMENTING PAST DEFORESTATION OF THE MISIONES RAINFOREST AND FUTURE SCENARIOS: IMPLICATIONS FOR SUSTAINABLE FOREST MANAGEMENT

María Fabiana Navarro Rau*, Noelia Calamari, María Jesús Mosciaro, José Norberto Volante and Gregorio Gavier-Pizarro

Increasing anthropogenic pressure on forest ecosystems continues transforming landscapes, threatening biodiversity and ecosystem services provision. The Misiones forest is one of the most threatened types of subtropical rainforests worldwide with remaining fragments representing approximately 7% of their original extension. Past and current trends suggest deforestation will increase due to expansion of agriculture and forestry activities. As part of the REDD+ National Strategy, a spatially explicit dynamic model of land use and land cover changes was used to provide past (2002, 2010 and 2016) and future scenarios of forest loss through 2030. Our objectives were to identify and quantify the main forces driving these changes, as well as determine the magnitude and spatial location of forest loss. We used Dinamica EGO for modeling, a cellular automata platform that considers neighborhood-based transition algorithms and spatial feedback approaches in a stochastic multi-step simulation framework. We defined biophysical, social-infrastructure, political-administrative variables and legal restrictions and applied statistical validation tests using 10% of the study area. For model calibration, we randomly selected one from 100 simulations for 2016, which was compared with the 2016 existing cover map. Based on this optimal performance of past simulations, three future scenarios were

developed (low deforestation, business as usual and high deforestation) to find out potential spatial patterns of forest loss for 2030. Additionally, we elaborated probability of deforestation and conversion maps from those 100 simulations. According to these scenarios, a deforestation around 19% is expected from either agriculture or forestry by 2030. The most conservative scenario indicated a recovery of 3% in native forest surface. Our results illustrate the suitability of the model applied to simulate deforestation processes. Further, it provides inputs for decision making involving the use of natural resources and potential impacts of those decisions over biodiversity and ecosystem services.

Keywords: *Deforestation, Dinamica-Ego, future scenarios, LULC change, Misiones Province.*

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Measuring and monitoring carbon stocks and ecosystem services in degraded forests under climate change

Chairs: Yasumasa Hirata and Alexia Stokes

DISTURBANCE IMPACTS ON CARBON STOCK AND TREE COMMUNITY COMPOSITION IN ANDEAN FORESTS IN PERU

Kazuki Miyamoto*, Tamotsu Sato, Edgar Alexs Arana Olivos,
Gabriel Clostre Orellana and Christian Marcel Rohner Stornaiuolo

As well as deforestation, forest degradation is posing threats to biodiversity in Andean forests. The Andean forests are distributed in a wide elevation range with precipitous topography and anthropogenic disturbances. In such a condition, decline in aboveground biomass (AGB) does not always function as a surrogate of forest degradation, partly because AGB decreases with increasing elevation. Meanwhile, tree community composition is receiving attention as a potential indicator of forest degradation. However, the validity of tree community composition as a surrogate of forest degradation is not sufficiently assessed in Andean forests. To assess the potential of community composition for evaluating the magnitude of forest degradation, we examined the influences of disturbances on community composition by a ground-based inventory survey setting plots across elevations ranging 600 to 3,500 m a.s.l. in Cusco region, Peru. Our analyses suggested that crop cultivation as a human disturbance affected community composition at mid and high elevations (1000–2400 m and \geq 2400 m), while erosion as a natural disturbance affected community composition at low elevation. The results suggest that different factors related to natural and human disturbances bring about changes in community composition and forest structure at different elevation zones in Andean forests, and community composition has a potential to represent forest degradation especially at higher elevation sites (\geq 1000 m) in Andean forests.

Keywords: *Biomass, biodiversity, carbon pool, community structure, REDD+.*

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PARTICIPATORY FOREST GOVERNANCE AND ITS CONTRIBUTION TO CLIMATE CHANGE MITIGATION AND ADAPTATION IN HIMALAYA

Bhagwati Joshi* and Prakash C. Tiwari

Mountain communities make implicit contribution towards sustainable development of their natural resources through forming a range of local institutions. In Himalaya exists the oldest form of institutional mechanism for participatory natural resource governance in the world. Village Forest Councils or 'Forest Panchayats' are the grass-root institutions for participatory management of forests with a long history of more than 100 years. Forest Panchayats represent one of the largest and most diverse experiments in a localized form of community forestry. More than twelve thousands Van Panchayats are not only contributing towards forest, biodiversity and water conservation; livelihood improvement and gender mainstreaming; but now also making innovative experiments in climate change mitigation and adaptation in Himalaya. A large number of Van Panchayats are now headed and managed by women, and thus reducing gender gap in natural resource management.

Study analyzes role, impact and effectiveness of Forest Panchayats in climate change mitigation and adaptation through empirical study of 100 Forest Panchayats in Uttarakhand Himalaya, India. Results indicated forest cover increased 7% to 15% during last 25 years that not only increased groundwater recharge, but also improved water availability (15%), increased agricultural productivity (10%), improved livelihood opportunities in traditional agricultural and forestry

sectors (25%), and enhanced community access to forest (21%). Regular income from forestry and farming sectors also reduced community-vulnerability to climate change (10%), and improved traditional adaptation practices. Increased forest cover enhanced carbon sink by sequestering carbon at rate of 3.7 t/ha/yr. This clearly indicates that Forest Panchayats have been successful in interlinking changing local needs, national development priorities and global environmental concerns at local level. These innovative experiments may go long way in climate change mitigation and enhancing adaptation capacity of communities by through adaptive natural resource management and improving livelihood opportunities all across the mountains regions particularly in develop.

Keywords: *Village Forest Councils; community forestry; biodiversity and water conservation; gender mainstreaming; traditional adaptation practices.*

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MODELING FOREST LANDSCAPES FOR PROMOTING OAKS IN A CHANGING CLIMATE

Louis R. Iverson*, Matthew P. Peters, Stephen N. Matthews, Anantha M. Prasad,
Todd F. Hutchinson, Joanne Rebeck and Jarel L. Bartig

Rising temperatures and variable precipitation events leading to droughts and floods will increase in frequency. We show evidence for increasing drought for much of the USA between two past periods, 1960-1986 and 1987-2013, and for three future periods, 2010-2039, 2040-2069, 2070-2099, using an index which combines both scores of monthly drought intensity and frequency. We also model and map potential changes in suitable habitat, adaptability, and capability to cope with a changed climate for 130 tree species (10x10 km) in the eastern United States. Overall, trends show many species with shrinking habitat but also several drought tolerant species (especially oaks) with increased suitable habitat. However, current oak regeneration is poor - hence management assistance is needed to ensure an ongoing, thriving oak component. Long-term research in southern Ohio, USA has shown that prescribed fire and thinning can provide a successful path for oak regeneration, but primarily on the drier moisture portions of the landscape. These data informed models of oak regeneration potential (10x10 m) across a 17-county region in SE Ohio. The ecomapping effort consisted of two parts: a GIS model of the terrain via derivatives of the 10-m DEM, and a stand inventory of current vegetation condition coupled with a decision support system to recommend needed silvicultural treatments. Silvicultural treatments promoting future increasers (e.g., oak) and finding refugia for decreasers can then be devised as means to adapt to the changing climate. Overall, these tools allow managers to identify 'zones of investment', i.e., those stands with a greater likelihood of growing into oak-dominated stands with minimal investment of scarce funding resources.

Keywords: *Forest landscape modeling, climate change, oak restoration, forest inventory.*

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FOREST CARBON STOCK MAPPING FOR IDENTIFICATION OF FOREST DEGRADATION USING LANDSAT DATA FOR REDD+ IMPLEMENTATION IN PERU

Yasumasa Hirata*, Luis Alberto Vega Isuhuaylas,
Lenin Cruyff Ventura Santos and Noemi Serrudo Torobeo

This study aims to develop a method for forest carbon stock mapping for identification of forest degradation using Landsat data for REDD+ implementation in Peru. We define forest degradation as a change to smaller carbon stock class for a certain period. We acquired Landsat images of Cusco, Peru, and field survey was carried out to estimate forest carbon stock. After atmospheric correction of Landsat data, we performed object-based classification using them. Statistics on reflectance in each band of satellite data were also calculated for those objects. We made an object-based model to estimate forest carbon stock from the satellite data by multiple regression analysis using the field-based carbon stock estimate as the object variables and statistics of satellite data as explanatory variables. Forest carbon stock in each object was divided into three class in highland Amazon forests and two classes for Andes forests, and classes of forest carbon stock were mapped. We identified and mapped changes to a small forest carbon stock using carbon stock class maps of two different dates to identify forest degradation. This approach makes it possible to introduce evaluation of loss by forest degradation in REDD+ monitoring system.

Keywords: *Forest carbon stock, REDD+, Landsat, forest degradation, mapping.*

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FOREST ECOSYSTEM RESPONSE TO FLOODING STRESS: AN EXPERIMENT SIMULATING CLIMATE-CHANGE-INDUCED EXTREME EVENTS

Ülo Mander*

In order to analyze forest ecosystems response to flooding-induced stress we conducted an irrigation experiment in a riparian forest (40-yr old grey alder (*Alnus incana*) stand) on former agricultural land in Estonia. Two experimental plots were established in 2017: a flooded plot (FP; 40×40 m; 2 weeks flooding, each day 55–70 m³), and a control plot (CP; 20×20 m). The study period was divided into three periods: pre-flooding (8 July–7 August), flooding (8–21 August) and post-flooding (22 August–7 November).

From 25 m eddy tower following fluxes were measured: CO₂ & H₂O (Licor Li-7200), CH₄ & N₂O (Aerodyne QCL-Tildas), BVOCs (PTR-TOF-MS). In FP, 8 microsites were equipped with automated soil chambers for CO₂, CH₄, and N₂O fluxes (Picarro 2508), tree stem chambers (TSC; 0.1, 0.8 and 1.8 m from ground), piezometers, automatic groundwater level wells, soil temperature and moisture sensors (0-10 cm). Four analogous microsites were established in CP. From TSC, during 25 campaigns daily and nightly CO₂, CH₄ and N₂O flux was measured. In each microsite, composite soil samples from 0–10 and 30–40 cm were taken for physico-chemical, N₂ flux and microbiological analysis in labs. In situ leaf photosynthesis activity of different plants was measured.

The forest sequesters C (NEE of CO₂ decreased during flooding) whereas CH₄, N₂O, methanol and isoprene flux showed slight emission. Soil CO₂ emission decreased and CH₄ fluxes increased when flooded. During flooding, N₂O flux in FP soil significantly increased whereas chambers in CP did not show any trends. Simultaneously, NO₃ concentration in soil of FP significantly

lowered and NH₄ concentration elevated in flooding, compared to CP. In FP, CH₄ and N₂O fluxes from TSCs of lowest positions increased during flooding. Due to flooding stress, photosynthesis activity of *Filipendula ulmaria* leaves significantly decreased. Results are used in C and N budget models.

Keywords: *BVOCs, CH₄; CO₂; N₂O; Nitrate.*

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FOREST REPLACEMENT TO YERBA MATE PLANTATION AND ITS EFFECTS ON ORGANIC MATTER

Sebastián Barbaro*, Silvia Santa Clara, Ramiro Marín, Alberto Sosa and Barbara Iwasita

The Province of Misiones occupies a region of subtropical climate corresponding to the selva Paranaense. Crops are mostly on red soil, belonging to Ultisol order. Additions of organic matter (OM) is drastically reduced when the original forest is replaced by crops, because the residues of the crops provide less volume of OM than the one added by the jungle. On the cultivation of yerba mate (*Ilex paraguariensis* Saint Hill) (YM), harvesting is the removal of the branches and leaves, therefore, the only carbon revenues came from the weeds growing in the spaces remaining between the liners of the plantation, the tillage system used to control these weeds will determine the speed of decomposition and soil cover, and will determine its fertility and productivity. Therefore, the different weed control strategies deserve to be studied to select those that minimize the degradation of soils, especially in the loss of OM caused by the replacement of native forest to production systems. The objective of this research is to generate information on the effect of weed control systems at YM on the OM of the soil. To achieve the goal some plots of YM with different systems of control of weeds were selected and soil samples were taken, and also INTA soil analysis information were used from Oberá area (INTA-UGD interinstitutional cooperation agreement). As partial conclusions, since the project is still in working, it could be said that a tendency exist towards a better quality of soil in plantations of yerba mate where their weeds are controlled with a rotary cutter.

Keywords: *Carbon, yerba mate, soil, management.*

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CARBON STORAGE IN NATIVE FORESTS WITH DIFFERENT CONSERVATION STATUS IN THE WEST OF THE PROVINCE OF CHACO, ARGENTINA

Marcos Antonio Atanasio*, Edgardo Aldo Alberto Leonhardt,
Lorena Pernochi and José Alberto Gobbi

Native forests are important reservoirs and carbon sinks due to the large amount of biomass they accumulate. The level of conservation of the same as a result of the use, determines the quantities of carbon stored in these ecosystems. In the present study, carbon storage was estimated in 18 landowners with high coverage of native forests characterized into 3 categories of conservation status based on indicators of structure, composition and functionality of the forest. The total area comprising the lands is 19,728 hectares, of which 87% is covered with native forests. Over a total area with native forests, 61% is in good conservation status, 29% in intermediate conservation status and 10% in unfavorable conservation status. By means of 16 sampling sites the carbon stored for each component tree, shrub, herbaceous, litter and dead wood was determined. The

values of carbon found above the ground indicate that the forest with a good conservation status stores 53.8 t C/ha, the forest with an intermediate conservation status of 41.1 t C/ha and the forest with an unfavorable conservation status 24, 9 t C/ha. A total of 814660.5 tons of carbon stored in an area of 17226 hectares was estimated, equivalent to 3 million tons of CO₂ fixed. This study shows that carbon storage is reduced in forests with unfavorable conservation status. It is suggested that for the conservation of them, the use of forests should be planned with guidelines of good management practices. In addition, the knowledge of carbon stores in different forest situations allows for different payment schemes for ecosystem services, when there are possibilities of implementation.

Keywords: *Carbon storage native forest conservation.*

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CARBON STOCK ASSESSMENT OF FORESTED AREAS ALONG A DISTURBANCE GRADIENT TO ADDRESS REFORESTATION AND AVOIDED DEGRADATION IN LEYTE, PHILIPPINES

Rizza Karen Veridiano*

The Philippines currently have 7.17 million ha of remaining forested areas, much of them are considered as secondary forests (previously logged) and the remaining are composed of agroforestry, plantations and wooded grasslands. The country has been engaged in international commitments and initiatives to halt deforestation, including - but not limited to - implementing REDD+, nation-wide reforestation programmes and conservation of key biodiversity areas. Case in point are the provinces of Leyte and Southern Leyte that comprise one of the largest remaining forested areas in the country. These provinces also represent different stages of the forest transition curve from less to heavily disturbed sites and reforested areas. Hence, it was fitting to use these provinces to investigate potential carbon stocks that could compensate for forest loss due to degradation. Within these two provinces 48 inventory plots (40 x 40 m) have been established that were randomly distributed over four forest strata with varying disturbance levels, including undisturbed forests, secondary forests, timber plantations and agroforestry areas. Biomass and carbon stock calculations were performed by using scientific nomenclature of trees, diameter at breast height and tree height. The results revealed that undisturbed forests have the highest carbon stock (493.91 t/ha on a plot level), followed by secondary forest (242.82 t/ha), agroforestry areas (37.87 t/ha) and lastly timber plantations (36.10 t/ha). The findings further indicated that agroforestry and timber plantations were not sufficient to compensate for avoided forest degradation. This finding therefore serves as a concrete basis for the local level policy makers to consider alternative options for restoration and reforestation to address loss due to degradation. Finally, we'll discuss how lessons learned from the study in Leyte can be potentially scaled-up to other provinces within the Philippines and other Asia-Pacific countries, especially those having similar configuration of disturbance gradients.

Keywords: *Carbon stocks, reforestation, avoided degradation, landscapes.*

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FOREST CARBON STOCK ESTIMATION USING ORIGINAL ALLOMETRIC EQUATIONS IN PARAGUAY

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Although the proportion of forested area has been reduced continuously during the last 30 years in Paraguay, information on forest carbon stock remains limited. To establish an MRV (measurement, reporting and verification) system for forest carbon change under the REDD+ implementation, we developed new regional allometry equations in three major eco-regions (Atlantic Forest, Humid Chaco, and Dry Chaco) in Paraguay. Several models were tested to predict total biomass using destructive sample data. We also conducted a case study to estimate total tree biomass (aboveground + belowground parts) in 33 sampling plots in Paraguay. The mean total tree biomass in Atlantic forests was about 70 Mg C/ha. On the other hand, Dry Chaco forests showed lower biomass (ca. 30 Mg C/ha) due to sparse stem densities and lack of large-diameter trees. Humid Chaco forests showed intermediate values between Atlantic forests and Dry Chaco (ca. 50 Mg C/ha). Our estimation is probably the first trial to specify forest carbon stock in Paraguay using a regional belowground allometry equation. We expect that our models will improve the estimation of biomass in Paraguay because they provide better estimates of total and aboveground biomass in each eco-region than pan-tropical generic models.

Keywords: *Allometric equations, biomass, carbon pools, Paraguay, sampling plots.*

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CARBON STORAGE POTENTIAL OF SEMI-ARID FOREST FRAGMENTS IN AN AGRICULTURAL LANDSCAPE OF NORTHWESTERN ARGENTINA

Patricia V. Zelaya*, C. Russo, N. Chacoff and R. Aragón

Forests play a key role in the regulation of the global climate, as they are important carbon sinks. At present, subtropical dry forests of the world face one of the most important transformations of their history due to the expansion of crops and pastures. As a result, an important fraction of the forest surface is today in the form of fragments of different size, shape and degree of isolation, immersed in an agricultural matrix. Therefore, it is important to know the role of these fragments as providers of this regulation service. In 3 agricultural farms in northwestern Argentina, we compared the carbon stocks in terms of biomass stored in three types of semi-arid Chaco forest fragments. We measured the diameter at breast height (DBH) of trees greater than 5 cm DBH in 12 linear forest strips, 5 small fragments (less than 0.10 km²) and 4 large fragments (larger than 10 km²) and by using allometric equations we calculated the stored biomass for each type of fragment. We found that, on average, small fragments stored more biomass (243.94 tn / ha) than large fragments (178.84 tn / ha) and linear strips (155.76 tn / ha). This biomass was concentrated in individuals of more than 10 cm of DAP in small fragments, while in linear strips and large fragments it was concentrated in individuals of more than 20 cm of DAP. In turn, differences in the amount stored between three types of forest fragments would be linked mainly to the type of management that is carried out after their establishment, and which varies among producers. Knowing the role of these increasingly common elements in the landscape in relation to the

provision of this regulatory service will help improve the management of these remnants throughout the region, and thus promote their long-term sustainability.

Keywords: *Carbon sequestration, dry Chaco remnants, Ecosystem services, agricultural landscape.*

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ABOVE-GROUND BOLE CARBON STOCK ESTIMATION USING FOREST INVENTORY AND REMOTE SENSING DATA FOR SECONDARY FOREST ECOSYSTEM IN IBADAN, NIGERIA

Ehimwenma Victor Aghimien*

Secondary forest ecosystem contributes to global climate change mitigation through carbon sequestration. However, information on Above-ground Bole Carbon Stock (AGBCS) for the International Institute of Tropical Agriculture, which hosts relics of the undisturbed secondary forest ecosystem in south-western Nigeria, has not been documented. Therefore, AGBCS of secondary forest ecosystem was estimated using forest inventory and Remote Sensing (RS) data. One hundred and forty plots of 50m x 50m were laid using systematic sampling technique. The Total Height (TH) and Diameter at Breast Height (DBH) of trees ≥ 10 cm were measured. Sixty wood core samples were randomly collected from dominant species at breast height for wood density. Pleiades satellite imagery was acquired using RS technique. The vegetation indices used for Above-ground Bole Biomass (AGBB) estimation were: Normalized Difference Vegetation Index (NDVI), Difference Vegetation Index (DVI), Infrared Percentage Vegetation Index (IPVI), Optimized Soil Adjusted Vegetation Index (OSAVI) and Renormalized Difference Vegetation Index (RDVI). Data were analysed using descriptive statistics and regression analysis. A total of 9,985 individual trees comprising 121 tree species and 30 families were recorded. The TH and DBH ranged from 4.70 to 39.30 m and 10.76 to 74.50 cm, respectively. AGBB and AGBCS ranged from 101.06 to 881,834.92 kg/ha and 50.53 to 440,917.46 kg/ha, respectively. The DVI had the highest AGBB value which ranged from 187 to 15,577 kg/ha, followed by IPVI, RDVI and OSAVI which ranged from 7,561 to 12,324 kg/ha, 64.0591 to 133.178 kg/ha, 0.0134 to 0.5621 kg/ha, respectively, while NDVI had the least values which ranged from -0.01 to 0.48 kg/ha. The best AGBB estimation model was $AGBB = \exp(3,496.61 + 0.99 \times (RDVI)^{1/2})$. The total carbon stock ranged from 11,035 to 18,774 kg/ha. Renormalized difference vegetation index was most suitable for estimating above-ground bole carbon

Keywords: *Carbon stock prediction, secondary forest biomass, vegetation indices, spectral reflectance, remote sensing.*

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PARTICIPATORY LANDSCAPE PLANNING IN PROTECTED AREAS – AN APPROACH TOWARDS BUILDING RESILIENCE TO CLIMATE CHANGE

Md. Shams Uddin*

Biodiversity conservation in the protected areas through land-use planning is becoming a versatile tool for forest ecosystems management. A Participatory Climate Vulnerability Assessment method was developed to engage local people and other key stakeholders in analyzing drivers of change (risks and vulnerabilities) and preparing comprehensive landscape-level plans for adaptation. Spatial, temporal, quantitative and qualitative tools are used for identifying ecosystem services and climate-related threats and vulnerabilities. This paper is based on a case study of one protected area in Bangladesh (Dudpukuria-Dopachari Wildlife Sanctuary). The process and outputs are described. Based on this the method is reviewed, along with participant views on the process and how the results have been used or not used to strengthen resilience. This provides lessons that are of wider relevance on local resilience planning for protected areas and biodiverse landscapes.

Keywords: *Climate change, ecosystem services, landscapes, land-use planning, protected areas.*

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Climate change and forest health: towards an effective policy decision making

Chairs: Pierre Sicard and Alessandra De Marco

EVALUATION OF SILVICULTURAL MANAGEMENT IN THE ECOLOGICAL REHABILITATION PROCESS OF THE LA POMA ECOLOGICAL PARK, COLOMBIA

Ingrid Janethe Molina Martinez*, Luis Jairo Silva Herrera and Ferney Augusto Rojas Ramirez

In recent decades, forests have been degraded rapidly due to anthropogenic activities and different natural phenomena, which is reflected in environmental pollution directly affecting ecosystems and in turn human welfare. There are ecological restoration techniques such as rehabilitation that is responsible for recovering the structure and function of degraded forest lands; these processes go beyond a plantation, the sowings must have management and monitoring in the short, medium and long term to achieve success. Therefore the scope of this project is to evaluate silvicultural management in the process of ecological rehabilitation with native trees and shrubs planted since 2000 in the ecological park LA POMA, located in the municipality of Soacha Cundinamarca, through the study of changes in the structure and floristic composition of the Montano Bajo dry forest (bs-MB). The study was carried out through the establishment of 6 plots, two in the reference ecosystem and the other four in reforested ecosystems with management and without silvicultural management, in which the vegetation record was taken and a detailed description of the indicators through descriptive statistics and analysis of variance tests - ANOVA, in the Bioestat 5.3 program. With this information, a conceptualization was developed to be applied in restoration strategies at local and landscape scales, and recommended the best adapted species for zones with similar characteristics (*Quercus humboldtii*, *Dodonaea viscosa*, *Abatia parviflora*, *baccharis bogotensis* y *Juglans neotropica*) and the most effective silvicultural techniques in the process of ecosystem rehabilitation led by the line of restoration and conservation of the CAEM under the “green leaves” restoration program.

Keywords: *Ecological rehabilitation, ecological restoration.*

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VULNERABILITY TO CLIMATE CHANGE AND FOREST DEPENDENT COMMUNITIES HOUSEHOLD LEVEL STUDY IN DROUGHT PRONE AREAS OF WEST BENGAL, INDIA

Jyotish Prakash Basu*

The forest dwellers are particularly at risk due to climate change. In India there are 1.73 lakh villages located in and around forests. The forest dependent communities in India vary from to 350- 400 million, most of which are underprivileged like tribals and others who are living in and around forest areas. The focus of the paper is to measure vulnerability indices at the household level and to address the developmental policy of the government of India for the reduction of vulnerability. The objectives of the paper are four fold. First is to measure household level vulnerability indices based on IPCC methodology using equal weights in the forest dependent communities in the drought prone regions of West Bengal. Second is to find out proportion of vulnerable households, moderate vulnerable households and high vulnerable households in the drought prone regions. Third is to determine the factors responsible for vulnerability to climate change at the household level. Fourth, the paper tries to examine the policies of the government of India to enhance climate resilience development.

Data were collected by conducting field survey in one of the drought prone districts, Bankura in West Bengal, India. This study was conducted in two villages in 2012. Total number of sample households was 120 and interview method was followed. The study area is Sal forest dominated area. In calculating the vulnerability index, we have followed an indicator based model using exposure, sensitivity and adaptive capacity of IPCC. In order to determine factors affecting vulnerability we have applied ordered Logit regression model. In this model we have chosen vulnerability indices as the dependent variable and age, sex, family size, education of the head of the households, food sufficiency less than three months, per capita income, number of income earners, drought rise, poverty, collection of non-timber forest products, livestock asset value of the household are the independent variables. Most of the households belong to high vulnerable categories. The socio-economic variables and climatic variables are the determinant of vulnerability at the household level.

Keywords: *Vulnerability, poverty, non-timber forest products, ordered Logit regression model.*

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CLIMATE RESILIENCE FOR HYDERABAD METROPOLITAN AREA BY ADAPTIVE MANAGEMENT OF URBAN RESERVE FOREST ECOSYSTEMS

Chandrashekar Reddy Gopidi*

Hyderabad Metropolitan (HM) city is endowed with as many as 194 urban forest blocks with an area of half a million hectares. Expansion of the city is making these urban forest reserves getting choked in concrete jungles. The health, structure and composition of urban forest reserves is threatened under the stimuli of climate change. The invasion of alien weed species which are relatively climate hardy, soil erosion due to high intensity rains, sparse regeneration of local species under climate stress, forest fires etc reduced the carbon sequestration potential of the forests and loss of biodiversity. This is impacting the delivery of Urban Forest Ecosystem Services (UFES) to ten million city population. The adaptive management practiced in 20 urban forest reserves include sustaining the fundamental ecological functions by restoring the hydrology, soil nutrient recycling, ensuring soil moisture availability and reducing fire incidents and impact of biotic interference from people, cattle, and weeds by taking up boundary demarcation and fencing and removal of alien invasive species. Biodiversity and the structure of the forest is improved by introducing climate hardy species and regeneration of existing rootstock. Engaged the neighbourhood people as partners in development and provided amenities for the environmental education. The user fee paid demonstrates willingness to pay for ecosystem services. User fee collected is utilised for maintenance of the facilities created. This concept is creating an enabling environment for replicability and scalability scope as there are 142 urban local bodies in Telangana state and most have urban forest reserves within 5 km radius. Adaptive management facilitates these urban forest ecosystems adapting to the changing climate, which in turn ensures HM city being climate resilient and environmental security for present and future generations in city.

Keywords: *Climate resilient city, people and urban forest reserves.*

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CLIMATE CHANGE IMPACTS AND ADAPTIVE CAPACITY OF TROPICAL FOREST ECOSYSTEMS AND LIVELIHOODS

Samuel Olumide Akande*

Climate change is posing threats today with widespread implications on the earth's ecosystems and livelihoods. However, the research motivation was based on only few available studies which have assessed the extent climate change and Green House Gases (GHGs) affect the ecosystem structure, and responses. The study examined vegetation changes and characteristics as a result of extreme climate events and anthropogenic activities on the environment. Primary data was obtained from randomly selected respondents within the forest communities while the sixty years (1973-2017) climatic data were obtained from the Nigerian Meteorological Agency (NIMET) analyzed using statistical techniques. The vegetation indexes were used and analyzed from the Landsat satellite images to quantify the changes in forest vegetation. A measure of climate changes, statistical correlations were established between the peak values of average seasonal and annual temperatures across the region. Results showed that the average temperature had increased significantly over the 45-year period. Normalized Difference Vegetation Index (NDVI), Integrated Forest Index (IFI), and Enhanced Vegetation Index (EVI), were calculated from Landsat at-sensor-reflectance data. It was observed that vegetation covers had shown a considerably low radiant temperature in all the years considered, areas of dense vegetation recorded less temperature amount of heat and surface structures through transpiration. The built-up areas, cultivated lands with its sparse vegetation (croplands) and exposed bared surfaces showed a significant increase in temperature over vegetation. The study concluded that climate change is reducing the natural ability of the forests to provide ecosystem services in the study area. Recommendations however were made for increased research effort, including increased resolution of climate models, better predictive capacity at a regional level for within and between-yearly climatic patterns, seasonality and extreme events. Collaborative monitoring programs for scientific researchers and policy-makers should be established for effective improvement on ecosystem services.

Keywords: *Ecosystem, livelihoods, vegetations, climate.*

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INCLUDING FORESTS ECOSYSTEMS INTO VOLUNTARY CARBON MARKET TO PREVENT DEFORESTATION AND CONTRIBUTE WITH SUSTAINABLE DEVELOPMENT IN PARAGUAY

Cecilia Pizzurno*

Paraguay is primarily best known as the eighth beef exporter worldwide of and the fifth worldwide exporter of soy. Land Use, Land Use Changes and Forestry sector (LULUCF) is the main driver of net greenhouse gases emissions to the atmosphere, followed by agriculture sector. For this reason, both the Chaco and the Atlantic Forest ecoregion in Paraguay have one of the highest deforestation rates in the world. Through a joint effort between organizations of the civil society of Paraguay and England, along with private actors enhanced with social and environmental responsibilities, are in their eight year of implementing the Paraguay Forest Conservation project. It has a total duration of thirty years and is the unique experience of voluntary carbon market in

Paraguay. This initiative applies the REDD+ (Reducing Emissions from Deforestation and Forest Degradation) approach, which reduction expectancy of CO₂ to be achieved is of 217.981 VCUs (Verified Carbon Units) and counts with international certification under Verified Carbon Standard (VCS) and Climate, Community and Biodiversity Standards (CCBS). Paraguay Forest Conservation project benefits Yshir indigenous communities in the Chaco and Pantanal ecoregions, protecting ancestral forests of upcoming deforestation and extends ancestral territory, as well as rural communities in the high threatened Atlantic Forest ecoregion in the south of Paraguay, through payment for ecosystems services related to native forest management. The voluntary market of carbon to avoid emissions of greenhouse gases into the atmosphere by means of conserving forests ecosystems, is not only a way to mitigate forests deforestation at a landscape level in two of the most pressured ecoregions in the world, but also provides resources for a sustainable development of different types of communities and safeguards the lasts forests ecosystems.

Keywords: *Voluntary carbon market, sustainable development, greenhouse gases emissions.*

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URBAN FOREST IN CLIMATE STRESS – THE POLICY OPTION'S

Hari Shanker Gupta* and A.K. Rastogi

The aggravating urbanisation is badly affecting India, also with projected urban population reaching 40%, by 2030. India's urban forest policy planners do face challenges for aiming at appropriate solution; given the numerous constraints. The effect of urban forestry on culture, livelihood, inclusivity of society, productivity of society, loss in social capital, health has been assessed in the Indian context, in the paper. Various provinces of India, are grappling with, Urban forest policy issues in the context of newer challenges of Climate Change – hence, devising policy tools- which attempt for “Effectiveness”, “Efficiency” and “Ecologically sustainability”. At national level, Prime Minister Council on Climate Change and its reflection through NAPCC (National), SAPCC (State) – offer prescription to urban forestry/greening. Important component of it “National Mission on Sustainable Habitat” – takes urban forestry upfront. Another component of NAPCC/SAPCCs its “Green India Mission”, deals with activities on Urban/Peri-urban/Institutional/Private urban lands for adding greenery in integrated manner. The use of urban waste water for urban green reclamation and improving the Air/water quality is notable development. Urban forested water supply catchments are being valued—as per survey, and are getting protected in turn. Indian cities are also having Climate Change Action plans—e.g., Delhi, Ahmedabad etc. Policy is moving beyond the “principled status” on “equity right on emission”, by making voluntarily ambitious plan on emission reduction, though efficiency, which reflect in urban green planning. The other innovative planning tools, tried in India are:

- Promoting urban amenities to Rural Area
- Attaining goal of energy efficient building/habitats
- Designing Urban greens/forest, as refuge to biodiversity, recreational place, reducing pollution, helping “Carbon sequestration.”

Keywords: *Policy, climatic action, plans, principles.*

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PRIORITIZING UNITED STATES TREE SPECIES FOR CONSERVATION ACTION IN THE FACE OF CLIMATE CHANGE AND OTHER THREATS

Kevin M. Potter*

Scientists and managers from throughout the U.S. Forest Service have developed a framework for forest tree conservation priority-setting assessments at risk from climate change and from pest and pathogen infestation. This Project CAPTURE (Conservation Assessment and Prioritization of Forest Trees Under Risk of Extirpation) framework is data-driven and guided by expert opinion, and allows for the quantitative grouping of species into vulnerability classes that may require different management and conservation strategies. The first application of this framework uses trait data and predictions of expected climate change pressure to categorize and prioritize 339 native North American tree species for gene conservation, monitoring, management and restoration. This categorization is based on risk factors relating to each species’ (1) exposure to climate change, (2) sensitivity to climate change, and (3) capacity to adapt to climate change. We used K-means clustering to group species into seven classes based on these vulnerability dimensions. The most vulnerable class encompassed 35 species that will require immediate conservation intervention. An additional application of this framework categorizes and prioritizes 419 native North American tree species using trait data and pest and pathogen threats for each host tree species. We used K-means clustering to group these species into six classes based on these three vulnerability dimensions. The two most vulnerable classes encompassed 14 species. These will require the most immediate conservation intervention. Other groups of species had traits associated with high sensitivity and/or low adaptive capacity to as-yet unknown pest and pathogen threats, suggesting that these species need close monitoring. This assessment tool should be valuable for scientists and managers determining which species and populations to target for monitoring efforts and for pro-active gene conservation and management activities in the face of multiple threats to forest health.

Keywords: *Conservation biology, forest health, genetic diversity, climate change, pests and pathogens.*

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CLIMATE CHANGE AS A MAJOR DRIVER OF LANDSCAPE CHANGE – INCLUDING VULNERABILITY OF COMMUNITIES AND REGIONS ASSOCIATED WITH DRIVERS AND RISK OF GLOBAL CHANGE

Edwin Ogar*, Agatha Agbor and Vincent Oyamo

Context: Nigeria has a land size of 923,768 km² and according to 2016 World Bank Report, the country has a population of 186 million people. Nigeria has three major vegetation belts namely mangrove in the coastal region, equatorial rain and savannah forest in the southern and northern belts respectively. According to Food and Agriculture Organization of the United Nations (FAO) report of 2005, Nigeria has the highest rate of deforestation in the world as between 2000 and 2005; the country lost 55.7% of its primary forests, and the rate of forest change increased by 31.2% to 3.12% per annum. Cross River State: Nigeria consist of 36 states and Cross River State, is a sub-national on the border with the Republic of Cameroon. The drivers of climate change (CC) in Cross River State are deforestation for farming, infrastructural development; forest degradation (timber and NTFPs harvestings) etc. and is a major driver of landscape change - including vulnerability of communities and regions associated with drivers and risks of global change as follows:

- a) CC caused drought, changed the landscape and turned green areas into brownish with streams and rivers dried up. This also contributes to diseases that kills trees.
- b) This dryness led to wildfire in farms/forest, loss of crops/wildlife, property and release of carbon dioxide.
- c) Low food productivity, food insecurity and hunger.
- d) Water bodies dried up results in scarcity of water, fishes for food and human consumption.
- e) Low food productivity and food insecurity among the teaming masses.
- f) CC led to severe storms, maimed, killed individuals, destroyed farms and property.
- g) CC contributed to flooding, submerge vulnerable communities, render the affected as refugees and relocation from ancestral homes.
- h) CC has led to loss of culture, medicinal plants and traditional ecological knowledge.

Keywords: *Climate Change, Deforestation, Forest Degradation, Drought, Food insecurity.*

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Large scale land use and change
models and forest carbon estimates

Chair: Jean P. Ometto

THE EFFECTS OF TREE-FALL GAPS DISTURBANCES ON THE CARBON CYCLE AND FOREST DYNAMICS OF TROPICAL FORESTS

Fernando Espirito-Santo*

Remote observation using light detection and ranging (lidar) offers a unique opportunity to quantify the geometry and size structure of tropical forests contiguously at fine spatial resolution. We used ten samples of airborne lidar data from tropical forests – six regions from Brazil, and other Neotropical forests such as Peru, French Gui, Panama and Costa Rica. We quantify gap size frequency distribution along vertical and horizontal dimensions in ten Neotropical forest canopies distributed across gradients of climate and landscapes using airborne lidar measurements. We found that natural forest disturbances (tree-fall gaps) follow a power-law distribution. Mean gap area (50 to 900 m square) and frequency (10,960 to 27,158) varied considerably among sites (200-ha each). However, we found that imposing a minimum gap area (20 m square) constrained the exponent of the power-law fit of gap frequency to a narrow range from -1.2 to -1.3. This contrasts with previous studies that included smaller canopy gaps (1-20 m square). The convergence of gap frequency distribution represented by the narrow range of the power-law exponents found in this study suggests an invariant scaling property of gaps in Neotropical forests. The invariant scaling property suggests a vertical compensation between frequency of disturbances and rate of growth and space filling. This compresses mechanisms that underlie changes on tree density (mortality and recruitment) and forest gaps (disturbance and recovery) into a relatively simple approach and highlights a way forward to predict disturbances in old growth forests by a structural canopy function – the tree size distributions expressed by forest heights. Our independent data of canopy openings shed light on the extent to which forests have experienced disturbances.

Keywords: *Lidar remote sensing, amazon, tropical forests, carbon, biomass and forest disturbances.*

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BIOMASS AND CARBON STOCKS OF NON-ARBOREAL COMPONENTS IN A TROPICAL FOREST

Simone Vieira*, Rafael Flora Ramos, Yvonne Vanessa Bakker,
Maíra de Campos Padgurschi and Carlos Joly

Forest inventories are regular for studies in tropical rainforest ecology and carbon dynamics. However, important forest compartments are frequently neglected. Understory, palms, tree ferns, lianas, bamboo, and epiphytes are abundant in these forests and mostly ignored. The Atlantic Rainforest, in Brazil, still holds great biodiversity despite centuries of human disturbance. The objective of this study was to investigate the contribution of these neglected compartments to the total aboveground live biomass (AGLB) in oldgrowth and disturbed areas of the Atlantic Rainforest. For this purpose, six permanent plots were sampled and AGLB for each compartment was estimated. Three plots were set on oldgrowth forests, one on a selective logged forest, one on a cut-off and now a late successional forest, and the last one on a cut-off/burned/pasture and now an early successional forest. Total AGLB in oldgrowth and disturbed areas varied between 128-310 Mg/ha. Understory (2 < DBH < 10 cm) sums 10-25 Mg/ha or 4-19% of total AGLB with great relevance in early successional forest. Palms (DBH > 2 cm) contributed with 0.1-13 Mg/ha or 0.08-6% of total AGLB. Otherwise, tree ferns, lianas (DBH > 2 cm), bamboo and epiphytes account for 0.06-0.3%, 1.5-2%, 0-6%, and 0.3-1.6%, respectively, of total AGLB. Despite

unequal contribution of individual compartments, their summation reach 28-44 Mg/ha, which means astonishing 13-22% of total AGLB. These results call attention to the great biodiversity found in the Atlantic Rainforest and the uncertainties in carbon stocks estimation.

Keywords: *Biomass, Atlantic Forest, palm, bamboo, epiphytes.*

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THE EFFECTS OF THE SPATIAL RESOLUTION OF AIRBORNE LIDAR DATA ON ABOVEGROUND BIOMASS ESTIMATION

Francisca Rocha de Souza Pereira*, Mauro Assis, Fernando Espirito Santo, Luciane Sato, Emily Dias, Aline Jacon, Heitor Carneiro, Roberta Cantinho and Jean Ometto

The amount of aboveground biomass (AGB) held in vital components of vegetation play a significant role in the carbon cycle of tropical forests. Reducing uncertainty of terrestrial carbon cycle depend strongly on the accurate estimate of AGB. Lidar remote sensing provides the most precise methodology to quantify AGB at large scales, but the effects of the spatial resolution of airborne lidar data on AGB estimation is unknown. Here we examine the impact of the minimum spatial resolution threshold of lidar data to reduce the uncertainty of AGB estimations in tropical forest. For that we used a sizeable airborne lidar data from Tapajos National Forest (TNF) and ten permanent field plots. We compared two approaches: (1) we used general lidar allometric equation of AGB estimation developed for the Amazon, testing the best spatial resolution of lidar measurements at 25, 50 and 100 meters and compared with our ground data of forest inventory from TNF; (2) we developed and tested a new local lidar allometric equation to quantify AGB in TNF. Although the use of lidar cloud cover at 50 m provides unbiased estimates of AGB, our results demonstrated that local forest structure plays a significant role in this general allometric equations. Our results underscored three conclusions. First, the effects of the spatial resolution of airborne lidar data on AGB estimation were significant. We found that a minimum size-area of 50 meters of lidar is necessary to produce an unbiased estimate of AGB in a local tropical forest of Central Amazon. Second, our adjusted allometric equation for TNF, which was based in mean canopy height model, reduced the uncertainty of AGB from RMSE%: 36.8% to RMSE%: 26.2% (local model). Finally, this study highlights the need of lidar allometric equations based on local forest structure to reduce the uncertainty of AGB estimations.

Keywords: *Aboveground biomass estimates, tropical forests, remote sensing, Lidar.*

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TRAINING A SATELLITE IMAGERY TEXTURE BASED APPROACH TO MONITOR AGB IN MANGROVE USING AERIAL LIDAR

Francisca Rocha de Souza Pereira*, Gregoire Vincent, Milton Kampel and Pierre Couteron

Mangroves are important intertidal ecosystems typically in tropical and subtropical regions. Their restoration and conservation are important for the regulation of carbon fluxes and climate change control, also to maintain their valuable services for the coastal zone. The main goal of this study is to investigate the potential use of textural indices derived from a very high resolution WorldView-2 image to estimate the aboveground biomass (AGB) of a mangrove forest in the Environmental Protection Area of Guapimirim (RJ, Brazil) subject to different levels of

disturbance. Fourier-based textural ordination (FOTO) and Grey-Level Co-occurrence Matrix (GLCM) textural indices were extracted from the panchromatic optical image. An accurate map of AGB was derived from lidar data and this map was used to train and test Random Forest, and AutoPLS methods to estimate AGB. The textural variability pattern associated with the canopy characteristics of the mangrove measured by FOTO and GLCM indices showed reasonable relationships with AGB. When many training points (from lidar) and both types of texture indices were used together the results improved markedly (RMSE (LOO) =25.64 t/ha, R^2 (LOO) =0.41). One source of uncertainty comes from the fact that degraded forests with low AGB values present coarse textures and can be confused with the textural pattern of high and more preserved forest characterized by large crowns. Our methodology can be applied to forests with different degrees of development but requires cautions for degraded forests for which texture gradients are not univocal. Nevertheless, the Random Forest classification based on the textural indices showed good results for the discrimination of different types of covers such as non-mangrove, altered and preserved mangroves. Efforts such as those developed in this work are necessary to quantify AGB and carbon stocks, for monitoring purposes, as to assist public policies for the conservation and protection of these ecosystems.

Keywords: *Aboveground biomass estimates, mangrove, Lidar, optical image, textural indices.*

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BRAZILIAN AMAZON BIOMASS MAP: USE OF LIDAR TECHNOLOGY

Jean Pierre Henry Balbaud Ometto*

The Brazilian Amazon is the largest continuous tropical humid forest in the globe, with an estimate of total biomass of 147.04 ± 4.81 Pg (Third National Communication of Brazil to the United Nations Framework Convention on Climate Change). Biomass maps present continuous values of forest biomass density, providing coverage over the whole region where the availability and quality of ground, inventory, data varies substantially. LiDAR technology, and associate remote sensing, is used to directly retrieve vegetation structure variables such as canopy height, number of individuals, and volume, and crown diameter, and indirect biophysical measurements, e.g., biomass, over a much larger geographical extent than plot-based forest inventories, potentially reducing the levels of uncertainty in forest biomass estimation. The biomass map was based in 1,000 LiDAR transects, randomly distributed across the 3.5 million km² of the Amazon forest, using as mask, the deforestation monitoring system map provided by the National Institute for Space Research (PRODES/INPE). The forest biomass is estimated at three different levels. At field plot level (first level), the data are used to validate the forest biomass estimated by LiDAR scanning (second level), based on equations and data provided by. A total of 407 field plots were used for this validation. The third level of forest biomass estimated is performed by extrapolating the forest biomass to the Brazilian Amazon Biome, by the use of MODIS vegetation index, Shuttle Radar Topography Mission (SRTM) data, precipitation data from the Tropical Rainfall Measuring

Mission and SAR (Synthetic Aperture Radar) data of the Phased Array type L-band Synthetic Aperture Radar (PALSAR). The correlation of the extrapolated data and the root mean squared error (RMSE), were R2 of 0.8059 and of 20.58 MgC.ha-1, respectively.

Keywords: Amazon, aboveground biomass, tropical forest, LiDAR.

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FOREST DEGRADATION EFFECTS ON CARBON BUDGETS FOR THE BRAZILIAN AMAZON

Michael Keller*

Tropical forests contain about one-fourth of total carbon stocks in land ecosystems and they are threatened by both climate change and continuing land use change. The largest area of tropical forest in any country, the Brazilian Amazon, is nearly 20% deforested. While annual deforestation rates in Brazil have decreased by about 70% since 2004, forest degradation processes including logging, fire, and fragmentation continue to deplete carbon stocks. Net carbon losses from degradation in Brazil and throughout the tropical forest region remain highly uncertain. Ground based forest inventories are scarce in the Amazon and have focused on undisturbed forests and well managed logging. Remote sensing approaches capable of covering the full region have presented highly variable estimates of degradation area. Extrapolations to carbon budgets require data on carbon losses from degradation that are also scarce and uncertain. Airborne lidar remote sensing potentially can greatly reduce this uncertainty in both classification of degradation and carbon stock estimation. I will present airborne lidar data showing how degradation affects both aboveground biomass and necromass. Based on lidar chronosequence data, I will also explore how fast forest biomass recovers from degradation. Finally, I will explore models that suggest that the large extent of degraded forests, if allowed to recover, could represent a substantial carbon sink over the next century.

Keywords: *Climate change, carbon, Amazon, Brazil.*

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POST-FIRE CHANGES IN FOREST BIOMASS RETRIEVED BY AIRBORNE LIDAR IN AMAZONIA

Luciane Yumie Sato*

Fire is one of the main factors directly impacting Amazonian forest biomass and dynamics. Because of Amazonia's large geographical extent, remote sensing techniques are required for comprehensively assessing forest fire impacts at the landscape level. In this context, Light Detection and Ranging (LiDAR) stands out as a technology capable of retrieving direct measurements of vegetation vertical arrangement, which can be directly associated with aboveground biomass. This work aims to quantify post-fire changes in forest canopy height and biomass using airborne LiDAR in western Amazonia. For this, the study evaluated four areas located in the state of Acre, called Rio Branco, Humaitá, Bonal and Talismã. Rio Branco and

Humaitá burned in 2005 and Bonal and Talismã burned in 2010. In these areas, we inventoried a total of 25 plots (0.25 ha each) in 2014. Our results showed that even ten years after the fire event, there was no complete recovery of the height and biomass of the burned areas ($p < 0.05$). The burned sites had significantly difference in height when compared with control sites. All burned sites had significantly lower biomass values than control sites. In Rio Branco (ten years after fire), Humaitá (nine years after fire), Bonal (four years after fire) and Talismã (five years after fire) biomass was lower than control sites. Fire impact associated with tree mortality was clearly detected using LiDAR data up to ten years after the fire event. This study indicates that fire disturbance in the Amazon region can cause persistent above-ground biomass loss and subsequent reduction of forest carbon stocks. Continuous monitoring of burned forests is required for depicting the long-term recovery trajectory of fire-affected Amazonian forests.

Keywords: Aboveground biomass, tropical forest, fire, LiDAR, degradation.

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DYNAMICS OF FOREST COVER, VOLUME, BIOMASS, AND CARBON IN THE BRAZILIAN NATIVE FORESTS: 1990–2015

Carlos Sanquetta*

Dynamics of forest cover, wood volume, biomass, and carbon stocks in Brazilian native forests from 1990 to 2015 were examined. Data source was FRA2015 Report (Forest Resources Assessment) submitted by the Brazilian Forest Service to FAO (Food and Agriculture Organization of the United Nations). The published data were analyzed critically, deductions of the parameters utilized and some adjustments in the calculations were performed. The area of native forests decreased over a period of 25 years, from 542 M ha to 486 M ha, corresponding to 10% of the initial forest cover in 1990. The greatest loss of forests happened in the Amazon and Cerrado biomes, which represented 85% of the total loss, reaching 56 M ha, equivalent to the Bahia State territory. Wood volume stock was reduced from 103 Gm³ to 95 G m³, or 8.45%, with the highest loss in the Amazon biome (79%). Total dry biomass stored in forests decreased from 126 G t to 115 G t, corresponding to 8.44%, with the highest reduction also in the Amazon (79%). Carbon stock diminished from 63 G t to 58 G t, a loss of 8.40%, which was more remarkably noticed in the Amazon biome (80%). It was concluded that the reductions in volume, biomass, and carbon are attributed to the reduction of forest cover in all biomes and that such reductions observed imply greenhouse gas emissions.

Keywords: *Biomes, forest cover, deforestation, carbon dioxide, emissions.*

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S 3.7

Innovative management approaches
in urban forests – Tools, processes
and solutions from green
to landscape infrastructure

Chair: Giovanni Sanesi

SPATIO-TEMPORAL ANALYSIS OF THE AIR POLLUTION REMOVAL SERVICE FROM THE URBAN FOREST IN CHILEAN CITIES

Cynnamon Dobbs* and Marcelo Miranda

One of the major environmental concerns in Chilean cities is air quality. Northern cities incur in air pollution emergencies due to movement of dust from the desert, center cities due to vehicle traffic and southern cities due to the use of moist firewood. The urban forest is one of the policies schemes developed for offsetting pollutant emissions in the last years. We conducted a spatial analysis of vegetation change over a 15-year period for 13 Chilean cities in a climate gradient. We evaluated changes I-Tree Canopy indicators for air pollution removal capacity from urban trees in parks, streets and peri-urban areas and we associated that to changes in respiratory diseases incidences using health statistics. Results in vegetation cover showed that half of the cities, mostly towards the south loss vegetation from the peri-urban area from urban sprawl. Most cities have a reduction in 10% of the street trees, while most cities had an increase in trees from urban parks, but only close to a 2%, not really compensating for the vegetation loss. This had consequences on the amount of removed air pollution, where northern and southern cities had a reduction on the capacity of trees for improving air quality and that had a relation with an increment in respiratory and heart diseases reported in the public health. The analysis showed that the compensation for pollutants emissions is not particularly been addressed by the planting of trees and probably by other schemes that are cheaper and more easily seen as a direct solution for air pollution reduction. These policy schemes should include the other services delivered by urban trees that will make them a more competitive for improving the quality of life in Chilean cities.

Keywords: *Urban Forest, ecosystem services, air pollution removal, offsets, land use change.*

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CELL HABITAT

Mariana Arteaga*

The human being has been able to transform absolutely his environment; arriving in the present, to a irreversible point; placing himself in a intangible moment, where the opportunity of revolve the direction of his actions is latent, but not stable. The historic ambition of man to absorb, manipulate and adapt the context to himself; it's an action that at pass of the centuries, has deformed the vision of "VITA". Taken by the religious, politics, social and economic approaches, it has distorted, mutilated and/or absolutely eliminated the original sense of coexistence.

¿What's happened with the sensorial approach, the ethereal, the perceptible? The question arises further of all explanation that any of this guidelines mentioned could offer.

While it is true that the deepening in the ideas of some American indigenous religions (México, Central, and south America) and the ancient civilizations at world level; shows tangibly the understanding and respect for the imperceptible energies that cohabit the space, valuing the importance of the natural envelope for the inherent development of all ecosystems, having achieved to establish a consistent nexus with the environment; starting from their essential thinking to the planning and territorial structuration, resulting in a coherent image that its empathic with the environment in which they were developed.

The predecessor reality of the contemporary existence embodies the antithesis of the substantial prefix; reflecting the lack of all that basic principle established, where the absence of territorial ordering, the excessive gap, social chaos and the null vivential approach of the urbanized modules; star the degenerative result of the vanguardist program of “Economic Progress”, same as specified as a scoop the Vita Artificialis and lacking values; defining itself as beneficial.

¿What are we?, ¿Are we conscious of our actions?, ¿Is there a future?. This last question, is the current paradigm; representing the antagonism of the human being to the surrounding environment. The return to the origin and to the primal existence, are the alphabet that marks the structuring axes of a new society.

Keywords: *Artificial life.*

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“BAREFOOT IN THE PARK” OR THE COMFORT OF NATURE IN CITIES: NEW EXPERIENCES, CHALLENGES AND DESIGN/MANAGEMENT IMPLICATIONS

Fabio Salbitano*

In the Anthropocene, the quest of nature in cities is becoming a key-issue for urban governance as well as a topic of growing attention for the community of citizens. Urban forests have a significant role on human health and well-being. Good Health, according to WHO, is “a state of complete physical, social and mental well-being”. An impressive number of studies have been conducted over the last two decades on the complex relationships between well-being and urban nature. Unfortunately, very little of the research knowledge is actually driving governance, design and management of urban settings where nature, and particularly urban forests, can be experienced by the citizens. The need of sustaining and guiding the improvement of the comfort of nature calls for action research programmes oriented to identify new tools merging governance styles with design/management issues where the role of people is empowered towards place making and place keeping approaches. Through some experiences of action research and by analyzing key case studies in Italy and South Europe, the aim of the contribution is to report new experiences and the next challenges oriented to highlight solutions about the comfort of nature in cities as well as to distill key issues for an inclusive design and management of urban landscapes where the comfort of nature is felt as a driving ecosystem service.

Keywords: *Thermal comfort, restorativeness, NBS, urban forest design, cultural ecosystem services.*

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NEW APPROACHES IN URBAN FORESTRY: EXPERIENCES FROM THE METROPOLITAN AREA OF MILAN (ITALY)

Giovanni Sanesi*

In cities of the third millennium, urban forests are acquiring an increasingly important role in terms of ecosystem services provision, countering global change impacts and improving quality

of life. Given the progressive limitation of public financial resources, the establishment and management of urban forests are becoming increasingly difficult to achieve. For these reasons, it is imperative to refer to innovative tools, processes and solutions that take into consideration the different actors operating in green infrastructure settings. The Metropolitan area of Milan is an interesting area of investigation where different solutions for the construction and management of urban forests can be found. It has become evident how by employing various methods citizens can positively contribute to making urban areas not only greener but also more culturally structured. In many cases there are also less formal landscapes of minor aesthetic value. Yet, those that are more effective in providing ecosystem services are able to guarantee a greater sense of identity and social cohesion. The presentation examines a number of experiences in Milan's metropolitan area from the past three decades.

Keywords: *Green infrastructure, ecosystem services, urban forests.*

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HISTORIC AND CULTURAL PERSPECTIVES ON PLANNING URBAN GREEN AND FORESTRY IN DENSELY POPULATED ASIAN CITIES

Peilei Fan*

This paper examines the impact of historic and cultural factors on patterns and processes of urban green and forestry development in densely populated Asian cities by using Taipei as a case. Taiwan is one of the most densely populated cities in terms of population per unit of urban built-up area, due to its large proportion of mountainous landscape in Taipei Metropolitan Area. As the capital of Taiwan, Taipei experienced the rapid industrialization, economic development, and urbanization in the past century, accompanied by dramatic institutional changes such as colonization by the Japanese government, the postwar government under the martial law, and the transition to democracy. This paper studies the main objectives and spatial patterns of urban green and forestry planning and its relationships to the general urban planning in different time periods. It investigates the complex interrelationships between economic development, urban planning, civic participation, and urban green space planning. It highlights the need to incorporate historic and cultural perspectives for a context-based urban green and forestry planning.

Keywords: *Green space, planning, urban, density.*

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URBAN TREES DATA FROM EDUCATION PROJECT

Yuri Tavares Rocha*, Patrícia Do Prado Oliveira and Gabriel Borges de Andrade Dayan

This urban growth in the region of the Atlantic Rainforest led to a major transformation in the natural landscape, forming a cultural landscape as any other metropolis. The city of São Paulo presents native flora and fauna that have managed to adapt to this transformation and the animals and plants that were introduced by their cultural, aesthetic and ecological values. The first step is to map the areas where plants and animals are distributed geographically. Since 2010, this technical and educational project had seen done with 283 undergraduate students the of course "Biogeography-Prof. Rocha" (<https://biogeografiausp.wordpress.com>, Geography degree/

University of São Paulo) in order to train the identification of species of animals and plants found in the neighborhood of your home and mapping of individuals by the Google Maps. To perform this activity, students are given instructions by field guide to observe aspects of the environment and plants studied. In six years of implementation of this educational project, have been identified 133 tree species from 47 families; 59% are alien species (from various parts of the world) and 41% are Brazilian species (from various natural regions). Although this project has been applied to undergraduate students during six years, results have been productive because they showed great interest, devotion and excellent learning about urban flora. This project constitutes a simple educational project, but totally viable in terms of time and financial support, extremely efficient to increase knowledge about urban plants, but more important generating rich information about surviving flora species in metropolitan areas. This activity has been shown to be a tool that can be used in the professional future of these students graduate, when they work as teachers, and perform the same project with their students.

Keywords: *Urban Biodiversity, urban biogeography, São Paulo, Brazil, urban flora.*

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PLOTTIER`S BOTANIC GARDEN IMPLEMENTATION TO SUPPORT THE REHABILITATION OF NATIVE FLORA IN NORTH PATAGONIA

Ana Faggi*, L. Datri, H. López, F. Aquistapace and J. Lecuona

During the 19th century river landscapes in the arid Patagonia have few trees among which the native willow (*Salix humboldtiana*) grew scattered among other plants. Europeans Settlers planted exotic willows and poplars to improve the climate conditions and to support the fruit production, giving rise to a typical woody landscape. The invasion of exotic willows and poplars displaced the native willow that has many competitive dispersion disadvantages. Since the last decades these formerly rural forested landscapes undergo transformations, due to urbanization and changes in land use, losing many ecosystem services. To try to reverse such a situation we proposed the creation of a botanical garden in the city of Plottier along the Limay River to support rehabilitation actions.

The garden is currently under participatory development between the Municipality and the University of Flores. It contemplates the creation of an in situ conservation area 5 ha big of ecological, recreational and cultural importance including trails and the design of a visitors center. The field data indicate that the riverside forests are composed mainly of species of the *Salix alba* complex - *Salix fragilis* and *Populus nigra*. The native *S. humboldtiana* represents 11% of the identified individuals and 10% of forest patches. Rehabilitation strategies include the control of *Populus nigra* and *S. babylonica* populations and soils conditioning, especially in the arid river border, where the native willow competes with more success than the rest. Activities of multiplication of the native willow to support ecological restoration of degraded areas will turn the garden into a center of dispersion of *Salix humboldtiana* to other areas of Patagonia.

Keywords: *Botanic garden, willow, restoration.*

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SOCIETAL PREFERENCES FOR HERITAGE TREE CONSERVATION SCHEMES IN HONG KONG

Junyi Hua* and Y. Chen Wendy

Heritage trees, commonly labeled rare, cultural or aesthetical trees, survive in hostile urban areas and provide extraordinary environmental, cultural, and social benefits to urban residents. Since 2004, about 500 heritage trees have been officially registered in Hong Kong, one of the densest cities around the world. However, polluted living environment, natural disasters, urban construction, vandalism and inappropriate management have brought tremendous pressures to the survival of these valuable living assets. As a result, the total amount of heritage trees in Hong Kong has declined to 474 at present and their living and health conditions are worsening at an increasing rate. There is no doubt that an in-depth understanding of how Hong Kong's general public perceives urban heritage trees' values is urgently needed so that individual's or community's potentially obstructionist approaches and actions can be counteracted, and constructive propositions can be formulated to facilitate the conservation of Hong Kong's heritage trees. Based on a questionnaire survey, local residents' one-off WTP for various conservation schemes is investigated by means of the dichotomous choice contingent valuation method. Respondents were required to choose one from three conservation schemes: to only remedy endangered ones, to maintain all living ones, and to systematically optimize the conditions of all living ones. 1040 valid responses including 198 (19.4%) protests were finally collected. The maintaining scheme was the most favored. The mean WTPs for the optimized and the maintaining schemes were HKD62.43 (approx. USD7.95) and HKD47.09 (approx. USD6.00), respectively, higher than that for the remedial scheme. The results show heterogeneous preferences for conservation schemes. The study builds a link between the natural-cum-cultural assets and policy-making from an integrated economic and social perspective and thus provides practical implications for heritage tree conservation in Hong Kong.

Keywords: *Heritage tree conservation, willingness to pay, societal preferences.*

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GROWING TREES IN PERI-URBAN AREAS: IGNORED OR FORGOTTEN?

Dhananjaya Lamichhane*

Increasing trend of rural-urban migration has caused rapid land-use change in peri-urban areas of the capital city of Kathmandu, Nepal. The paper elaborates the need for change in urban authorities and residents for growing trees in peri-urban areas in the future. Five different study sites representing diverse geophysical and socioeconomic strata were sampled out. Methods included literature review, street/transect walk, comparative interviews between younger and elder people, area estimation and recording of trees/plants, and change analysis based on periodic maps. Results show that eighty percent of the households don't think of growing trees while building their houses and five percent have opinion of need for trees around but no planting due to lack of space or appropriate tree species. Out of total, 20 percent have green space with some flowers and vines. Households having more than 200 square meters area have home yards, and have planted 1-2 tree species (i.e., more than 5 meters height in maturity). People are more interested in planting religiously important trees such as sandalwood (*Santalum album*),

Elaeocarpus sphaericus, and wood apple (*Aegle marmelos*). Frequency of popularly grown religious tree pairs (*Ficus benghalensis* & *Ficus religiosa*) that are now old and hazardous, is rapidly declining mainly due to their large size and root effects. The number of urban trees are positively correlated with household land size and not correlated with size of public land. Governmental and municipal authorities should have programs for awareness, seedling subsidy or other incentives, and mandatory provision in designing, building and granting completion certificate of new buildings or houses. Factors like population pressure, high demand of small size land, fragmentation of landscape, lack of housing standards and collective action between neighbors, and people's habit of sun basking are not to be ignored by authorities and forgotten by residents in the future.

Keywords: *Peri-urban, trees, Kathmandu, household, greenspace.*

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ENERGY SAVING POTENTIAL OF FRAGMENTED GREEN SPACES DUE TO THEIR TEMPERATURE REGULATING ECOSYSTEM SERVICES IN THE SUMMER

Fanhua Kong*

Urban green spaces help moderate the urban heat island effect (UHI), providing important temperature regulating ecosystem services and resulting in associated savings in cooling energy. However, because these temperature regulation benefits lack clear market prices, they are rarely incorporated into urban planning actions. Green spaces can generate a three-dimensional (3D) cool island that could reduce the cooling energy requirements within and around urban areas, but the 3D cooling effect has not been considered in previous studies quantifying energy savings from green spaces. This study presents a new and simple approach to quantify potential energy savings due to the temperature regulating ecosystem services of small-scale fragmented green spaces through the 3D simulation of the outdoor thermal environment on selected summer days in Nanjing, China. A field survey was conducted using the microclimate model ENVI-met to examine outdoor 3D thermal environmental patterns at the inner-city Gulou Campus of Nanjing University under two different scenarios: "with" and "without" green spaces. The modeling results were used to quantify potential cooling energy savings from the temperature regulation ecosystem services of green spaces on the outdoor urban environment. Subsequently, the accumulative temperature reduction achieved through the green spaces was calculated based on a regression model. The results show that, in the horizontal direction, the simulated distribution of wind speed and mean temperature at 1.5 m height was closely related to the spatial distribution of the underlying surface types. The removal of green spaces increased mean air temperature by 0.5 °C (33.1 °C vs. 33.6 °C). In the vertical direction, the removal of green spaces had little effect on the near-surface wind field; however, above the surface, the turbulence perpendicular to the main wind direction was significantly increased. Quantification of the cooling benefits of green spaces in relation to the mean height of buildings on Gulou Campus yielded 5.2 W/m² cooling energy, saving 12852.1 kWh during a single daytime under the hot summer temperatures.

Keywords: *Energy saving, ecosystem services, cooling effect, ENVI-met.*

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OP 3.1

Climate change as a major driver of landscape change – including vulnerability of communities and regions associated with drivers and risks of global change

Chair: Louis Iverson

LANDSCAPE MANAGEMENT STRATEGY TO COMBAT CLIMATE CHANGE INDUCED VULNERABILITIES OF COMMUNITIES AND ECOSYSTEMS IN INDIAN HIMALAYAS

Pratishtha Singh*, Vipul Sharma and J. S. Rawat

The Indian Himalayan Region (IHR), one of the global biodiversity hotspot is endowed with a number of life-sustaining natural resources and spreads over more than 0.537 million km², which is 16.2% of the total geographic area of the country. With more than 41.5% of its geographical area under forest cover, the region accounts for one third of the forest cover of India. The IHR is also home to 40 million people. A majority of this population is dependent on natural resources for meeting their daily livelihood requirement. This makes it more vulnerable to climate change in the context of the higher climatic fragility of the natural resource base. Nearly 17% of its area is under permanent snow cover & glaciers and about 30-40% under seasonal snow cover. The estimated annual run-off from the Himalayan Rivers is approximately 1,600,000 million m³ and is a source of water for irrigation, household use and hydro-power services for local and downstream populations. The IHR is threatened by changing land use patterns, pollution, unprecedented glacier melting, floods, landslides and biodiversity loss. This paper analyses the impacts of climate change and drivers of biodiversity loss. It discusses the importance of including landscape management strategy as a critical tool for increasing resilience to climate change in Indian Himalayan Region for adaptation planner in policy framework and further research.

Keywords: *Indian Himalayan Region, landscape, climate change, vulnerability, adaptation.*

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PEOPLE PERCEPTION OF SOCIOECONOMIC IMPACTS OF DEFORESTATION AND FOREST DEGRADATION IN THE CONFLICT-AFFECTED REGION OF NORTHWEST PAKISTAN AND A STEP TOWARDS ADAPTATION: A CASE STUDY OF DISTRICT SWAT (2011–2016)

Owais Syed Muhammad* and Saima Siddiqui

This work aims to know people perception of socio-economic benefits of deforestation, its negative impacts, and sustainable forest management. The people perception about deforestation and its impacts has been collected through questionnaire survey from randomly selected villages starting from Lower Swat to Upper Swat. The local communities believed that natural vegetation starts to decrease when the Princely State of Swat was annexed with Pakistan and the forest sector came under the umbrella of the forest department. However, most of the respondents have of the view that depletion of natural vegetation results in loss of biodiversity, climate change, warming of the summer season, a decrease in winter precipitation, ground and surface water depletion, lack of wood for Shelter, especially in lower Swat. Generally, the local population believed that this deterioration in the climate and environment was due to ruthless cutting, population pressure, increase built-up areas and commercial activities, glacial retreat, soil degradation, lack of basic facilities, poor management of natural resources and unawareness about the role of forest resources, climate change, and sustainability. The major stakeholders like local government, forest official and Non-governmental organization is required to invest massively on reforestation project with the involvement of local communities, protection and honestly management of forest

resources, biodiversity conservation in order to mitigate to climate change and secure the lives of the inhabitants against natural hazards.

Keywords: *Socioeconomic, sustainable, management, conservation, natural hazards.*

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ANALYSIS OF ECO-HYDROLOGICAL PROCESSES RELATED TO TREES AND SOIL WATER DYNAMICS

Laura Benegas Negri*

Trees affect water cycle through interception, evapotranspiration, and infiltration, and thus the amount groundwater and surface watercourses. Although benefits forest and scattered trees are acknowledged, a balance between conservation and restoration is needed as a way to reduce pressure to forest conversion. To contribute to the understanding of the role of trees at low densities on soil water dynamics I explored a new conceptual model relating the effect of vegetation on the spatial variability of $\delta^{13}C$ -excess (water stable isotope signature) and soil water content (SWC) together with a combination of measurements taken in two contrasting locations; one agroforestry coffee farm in Central Costa Rica, and a pasture landscape with scattered trees in Copan, Honduras. Measurements included soil infiltrability, SWC, preferential flow and water stable isotopes analyzed from an eco-hydrological approach linking water cycle processes mediated by trees. Trees favored higher infiltrability and preferential flow in the agroecosystem with soil degradation but gave no difference in infiltrability in the coffee agroforestry system. There was lower surface soil moisture under trees than underneath coffee due to tree's greater transpiration, and the preferential flow was greater under coffee shrubs than neighboring trees, during the dry season. The negative trend between SWC and $\delta^{13}C$ -excess of surface soil water under trees during the dry season indicate enhanced evaporative losses under defoliated trees in the agroforest. But, a positive trend between the surface SWC and $\delta^{13}C$ -excess under coffee shrubs indicate an enhanced process of canopy interception and throughfall, during the dry season. There was a positive relationship between $\delta^{13}C$ -excess and SWC underneath trees during the wet season, indicating processes of throughfall and stemflow of intercepted water. Promoting trees, especially in degraded pastures, may help to face the anticipated increase in heavy precipitation for Central America due to climate change, reducing forest pressure due to agricultural expansion.

Keywords: *Hydrological processes, trees outside the forest, water.*

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CONSERVING FOREST BIODIVERSITY AND MAINTAINING LIVELIHOOD SECURITY OF THE VULNERABLE POPULATION IN THE WESTERN GHATS UNDER A CHANGING CLIMATE

Shadananan Nair Krishnapillai*

In the Western Ghats Mountain forest of India, a recognized global biodiversity hot spot, changing climate together with environmental degradation is a threat to the biodiversity, affecting national

economy and the livelihood of indigenous and poor people depending on forest resources. Climate extremes, unsustainable use of resources and unwise government policies pose serious threat to the existence of many rare and costly medicinal plants, herbs and precious trees. Encroachment and introduction of plantation crops lead to the depletion of vast area of natural forests. Poachers have widely destroyed the precious trees such as sandal, rosewood and teak. Major hydropower projects submerged large areas of forests and displaced thousands of poor living in harmony with the nature, leading to disintegration of community-based resource management. Rainfall in the region is becoming more seasonal and intense, resulting in the erosion of the already degraded soil. Because of long dry season and falling groundwater storage, seasonal plants become extinct. Forest fire has become more frequent. Shift in regional climate may affect the biodiversity in future. The rules and regulations aimed at protecting the forests and green cover become farce because of weak administrative mechanism, corruption and vested political interference. Sustainable utilization of forest products may boost the current economic development and help alleviating poverty of the forest-dependent communities. There are large areas of restorable degraded forests and afforestable wastelands. Community forest projects with the cooperation of local population could improve livelihood conditions of the poor. In the schemes for adaptation and impact mitigation, vulnerable people like the forest dwellers are often neglected. Present paper is an assessment of the impact of climate change and environmental degradation on the Western Ghats forest. Current policies and strategies related to climate, forest and environment have been critically reviewed to suggest guidelines for an appropriate forest policy.

Keywords: *Climate change, forest biodiversity, vulnerable population, adaptation, policy.*

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BUILDING CLIMATE-RESILIENT ECOSYSTEMS AT PROTECTED AREAS IN BANGLADESH

Md. Shams Uddin*

Traditionally forest dependent community use forest goods and services for their livelihoods. However, when a forest declared as protected area, it creates conflicts between the forest dependent communities and forest managers. In this paper we tried to explore to what extent protected area of Bangladesh is providing ecosystem services for livelihood resilient of the forest dependent communities. The study is based on a case study from a north-east protected area, i.e. Lawachara National Park (LNP). We used face-to-face interviews with forest dependent communities, Forest Department (FD) officials, Co-Management Committee (CMC) members and through review of relevant published materials. Our study reveals that ecosystem services of LNP, especially the provisioning services (e.g., timber, fuel wood, bamboo, medicinal plants, cane, sun grass, vegetables), and cultural services (eco-tourism, wildlife education and research), are contributing significantly in poverty alleviation of local forest dependent communities. At LNP, ethnic communities within the park and landscapes people are depended on these services

100% and 76% respectively. The study stresses that necessary attention is required from the policymakers and forest managers to enhance the supply of ecosystem services that will contribute resilient livelihoods of dependent community at LNP and other PAs of Bangladesh.

Keywords: *Protected Area, resilient livelihood, ecosystem services, biodiversity conservation, eco-tourism.*

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OP 3.3

Fire dynamics – impacts
in forests and people

Chairs: Dolors Armenteras and Fabio Salbitano

MODELING FIRE IGNITION PATTERNS IN MEDITERRANEAN URBAN INTERFACES

Mario Elia*, Vincenzo Giannico, Raffaele Laforteza and Giovanni Sanesi

The rapid growth of built-up areas and infrastructure in the Mediterranean environment has resulted in the expansion of urban interfaces where fire can ignite and spread. Within this context, there is a need to understand spatial patterns of ignition distribution and the relative importance of influencing drivers. In response to this need we developed an analysis of fire ignition patterns using human and biophysical explanatory variables by firstly developing two different linear models to assess patterns of fire ignition points in terms of occurrence (presence/absence) and frequency (number of ignition points per area and secondly applying statistical tests to both models to evaluate the most important human and/or biophysical drivers influencing these patterns. The probability of ignition point occurrence and frequency were mapped using the predicted values of the two models in the Apulia region (southern Italy). Our findings revealed that dependent variables (fire ignition occurrence points and frequency) are negatively correlated with population density, but positively correlated for presence of urban areas with a significantly higher likelihood of ignition in cultivated (crop)land, forest, shrubland, grassland, and other natural spaces. The probability of ignition increased with elevation and slope. The maps show that the probability of ignition occurrence is relevant along the coast in the northern and southern parts of the region, especially in urban interfaces with a strong presence of shrubland and Mediterranean maquis. Ignition point frequency was predicted along the coast, particularly in the south and in some densely urbanized inland areas. By adopting the models, forest managers and decision makers may avail of the knowledge gained to design and promote sustainable fire management strategies in the Apulia region.

Keywords: *Fire; ignition points; Logistic regression; Poisson regression; urban interface.*

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CLIMATE AND TROPICAL DRY FOREST FIRE REGIME IN THE UPPER MIDDLE MAGDALENA RIVER VALLEY, COLOMBIA

Julian Díaz-Timoté* and Angela Parrado-Rosselli

Causes of wildfires in tropical dry forests have been mainly attributed to land use change, while few information exists on the influence of climate on fire occurrence in these forests. We characterized fire occurrence and extent between 2000 and 2018 in the tropical dry forests of the Upper Magdalena River Valley in Colombia, and analyzed its relationship with annual and supra-annual variability of climatic variables such as precipitation, temperature and evapotranspiration. Using 18 years of high-quality satellite imagery and Moderate Resolution Imaging Spectroradiometer (MODIS) we identified burned area, frequency and spatial pattern of fires, and were associated to temperature, precipitation, and evapotranspiration. Results showed 232 fire events, with no particular pattern of spatial distribution. We found a positive correlation between previous-month's temperature and fire occurrence (number of fires and area), as well as between fire and real evapotranspiration. Major fire years tended to follow the switching from La Niña to El Niño conditions (e.g. 2002-2003, 2006-2007, 2009-2010), probably due to higher fuel produced during the rainy season of La Niña, which when desiccated by the dry El Niño

conditions created conditions for widespread wildfires. Considering the increasing frequency of extreme El Niño events due to climate change, results of this research should be considered in future risk maps and in restoration strategies of tropical dry forests.

Keywords: *Climate anomalies, El Niño southern oscillation, fire occurrence, MODIS, multitemporal analysis.*

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EXPLORING THE CONCEPT OF FIRE PROTECTION ECOSYSTEM SERVICE IN CHANGING FORESTED LANDSCAPES

João Azevedo*, Paulo Fernandes, Ana Paula Rodrigues, Joaquim Alonso, João Honrado, Ajith Perera, and Ângelo Sil

Landscapes and ecosystems play an important role in fire regulation and in the mitigation of potential negative effects of extreme fire events. Fire protection regulated by ecosystems and landscapes can thus be considered as an ecosystem service with significant benefits for humans' safety, health and economy. Although fire is an important ecological process in most of the planet, fire regulating and protection by ecosystems and landscapes from an ecosystem service conceptual framework perspective have been insufficiently addressed in the literature. In this research we explore the concept of Fire Protection Ecosystem Service (FPES) based on the Fire Regulation Capacity (FRC) and their application in the assessment of socioecological effects of landscape change in mountains landscapes facing rural abandonment. We analyzed responses of FRC and FPES to changes in the landscape structure based on modeling using BFOLDS-FRM for years 1990 and 2006, and three landscape scenarios for 2020 under extreme fire weather conditions. FPES supply and economic value were assessed based on proxies of FRC (burned area and fire intensity) and economic damage caused by fire. Fire events over 100 ha increased in the area since 1990, indicating a reduction in the capacity of the landscape to regulate large and extreme fires, which may decline further in future landscape scenarios. The supply in the FPES is expected to decrease in the area, particularly when fuel builds up and becomes spatially connected in the landscape. The economic value of the FPES is also expected to decrease over time, despite the differences observed among scenarios. Planning and management of mountains regions experiencing change through abandonment (aggravated by future climatic conditions) must take into account trends and patterns in fire regulation and protection to sustain and enhance the provision of ecosystem services in general and promote sustainability in Mediterranean mountain areas.

Keywords: *Portugal, fire behavior modeling, ecosystem services assessment, mountain landscape change.*

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SOIL, BUT NOT AIR, TEMPERATURE DIFFERS BETWEEN BURNT AND UNBURNT PATCHES IN A NEOTROPICAL RAINFOREST

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Anthropogenic fires may have strong and long-lasting negative effects in tropical rainforests. Such effects are not necessarily restricted to the burnt areas: edge influence from the burnt patch may significantly alter the unburnt vegetation, but remaining forest patches may improve microclimate conditions in the adjacent burnt areas. We studied variation in air and soil temperature in burnt and unburnt areas in the Atlantic forest of southern Bahia, Brazil. In November-December 2017, approx. two years after a series of wildfires, we sampled six transects at three burnt-unburnt edges. At each transect, we placed one pairs of dataloggers at the edge and at 20, 60, and 120 m into the burnt and unburnt areas, thus using 14 dataloggers per edge. One datalogger of each pair was buried at a depth of approx. 5 cm and the other was kept at a height of 1 m above ground. We sampled one transect at a time, keeping the dataloggers there for seven days and then transferring them to another transect. We then used generalized linear and additive mixed models to assess differences between the burnt and unburnt areas and gradients in temperature, which would indicate edge influence. We did not detect gradients in either air or soil temperature. Air temperature was similar among the burnt and unburnt areas, except for minimum temperature, which was slightly higher in the unburnt forest. Conversely, maximum soil temperature and variation in soil temperature was greater in the burnt area than in the forest. These effects on soil temperature are likely due to the changes in vegetation structure, as the burnt area is dominated by a native bracken fern. In turn, they may hamper plant regeneration and alter the soil fauna. Additional studies on vegetation structure, seed rain, and soil fauna are also being carried out in these areas.

Keywords: *Edge effects, soil temperature, air temperature, fire ecology.*

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EVOLUTION OF LANDSCAPE RESILIENCE TO WILDFIRES IN SPAIN (1956–2018): A BRAND NEW METHODOLOGICAL APPROACH BASED ON SISPARES LANDSCAPE MONITORING SYSTEM

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Ramón Elena-Rosselló and Alejandro Rescia

Socio-economical changes in Spain, since 1950, involve urban population growth in the most industrial and touristic zones and migration out from rural poorer regions. Subsequently landscape distribution became deeply polarized by two rural processes: intensification or abandonment of the agrarian systems. One of the most serious effect, in both biophysical and socio-economic dimensions, is the growing vulnerability to wildfire, expressed in number of ignitions and burnt land extension. This is particularly worrisome in Spain, where almost 2 million hectares have been burned. In addition, according to recent reports, climate change would aggravate this problem. In this context, it appears to be urgent to develop socio-ecological management guidelines to assess the evolution and current spatial structure of the rural landscapes in the most vulnerable areas considering that this structure determines its fire regime.

In this study, 68 samples of 4x4 km² of SISPARES (<http://www.sispares.com/>) located in the Northwestern bio-geo-climatic eco-regions in Spain, have been studied aiming to characterize the

dynamics of the spatial pattern of rural landscapes from 1956 to 2018 in five dates. We applied different landscape indices (fragmentation, contagion, diversity among others) to determine quantitatively the structure of these landscapes and, then, establish their spatial resilience to fires. This spatial resilience, defined as the way in which the spatial organization of a system influences its capacity to recover its normal state once the degrading disturbances have disappeared (in this case, fires) and to bounce back in the wake of stress produced by them, was determined selecting a set of landscape indices, taking into account that indicators that favor fire frequency contribute negatively to resilience whereas indicators that disfavor fires events contribute positively. Indices selected were based on previous studies on vulnerability of landscapes to ignition frequency.

Keywords: *Ecoregions, fire frequency, spatial resilience quantification, vulnerability.*

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GERMINATION RESPONSE TO HEAT SHOCKS OF FIVE LEGUME SPECIES OF COLOMBIAN TROPICAL DRY FORESTS

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Fire regimes of tropical dry forests of Colombia are not well known and there is still a debate if fire has been a frequent natural disturbance. Consequently, whether plant species of this ecosystem have specialized fire-response traits, such as heat-stimulated germination is also poorly understood. As germination of several legumes in fire-dominated ecosystems is stimulated by fire and heat shocks, the objective of this research was to evaluate, for five legume species, common to the tropical dry forests of the Upper Magdalena River Valley in Colombia, the effect of heat shock on seed germination. We exposed 810 seeds per species to nine experimental heat shock treatments (i.e. 80 °C, 100 °C and 140 °C for 1, 3 and 5 minutes). We then incubated the seeds in an acclimatized germination chamber. Seeds were also classified into seed size classes (i.e. small, medium and large) in order to test if germination response was correlated with seed size. Results showed that germination of all seed species was stimulated by heat; however, germination percentages of *Albizia niopoides*, *Pseudosamanea guachapele* and *Piptadenia* sp were higher under less-intense heat treatments. In contrast, *Enterolobium cyclocarpum* and *Chloroleucon manguense* exhibited a better germination response under high temperatures (100 and 140 °C for 3 and 5 minutes). Seed size did not correlate with germination response. Our findings indicate that some tropical dry forest legumes might have an adaptive advantage to forest fires, which are expected to become more frequent and intense even in nonfire - prone environments due to climate change.

Keywords: *Seeds, fires, sensitivity, mimosoideae, size.*

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EFFECT OF FIRE ON WOODY SEEDLING ESTABLISHMENT IN A COLOMBIAN TROPICAL DRY FOREST

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In fire-influenced ecosystems some plant species have the ability to recover, germinate and establish after a fire; however, their proportion and dominance varies between sites. Currently, there is a debate on the influence of fire in Colombian tropical dry forests and if the vegetation has the capacity to regenerate after fire. In that way, the objective of this research was to compare natural regeneration following a fire in a tropical dry forest of the Upper Magdalena River Valley in Colombia. To do so, all seedlings and saplings of woody species were recorded 1.5 years after a fire in 75 2x2m plots installed in burned and unburned sites. Results showed that species richness was lower in burned sites, but the number of individual per species was higher than in unburned areas. *Machaerium capote*, *Cordia alliodora* and *Casearia corymbosa* which are representative species of tropical dry forests were highly abundant in the burned plots, while poorly represented or absent in the unburned ones. Although the long-term fate of post-fire seedlings is not known, results of this study provide evidence that some tropical dry forest trees have fire-tolerant traits that should be considered in restoration programs, in light of future and more frequent forest fires due to climate change.

Keywords: *Fire stimulated germination, regeneration, fire-tolerant traits, recruitment, saplings.*

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THE CHILEAN PATAGONIA LANDSCAPE POST MEGA-FIRES: UNDERSTANDING THE SPATIO-TEMPORAL PATTERNS

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In Western Patagonia (Aysén Region, 43° - 48° S), the most extensive and intense forest fires (around 3,000,000 ha) recorded in Chile occurred between the 1930 and the 1950 decades. These forest fires were caused by pioneers and ranchers who sought to enable grasslands for livestock and urban settlements, for which the forests were an impediment. Although more than half a century has passed since these fires occurred, the affected ecosystems have not been fully recovered. Despite the ecological and economic importance of the ecosystems that were burned, these have not been studied at the landscape scale. The main objective of this work was to establish the post-fire effect on the spatio-temporal patterns of the landscape during the last three decades (1980-2016). The Province of Coyhaique, Aysén Region (44° - 46° S) was selected as the study area, because it is a zone highly transformed by fires. Landsat satellite images were used to generate land cover and land use maps. Changes in land cover and land use were evaluated by identifying the trajectories that occurred between the years 1986 and 2016. To understand the spatial patterns, was selected the following commonly used metrics at landscape and class levels: Number of Patches, Mean Patch Area, Largest Patch Index, and Proximity Index. I first found that the landscape has lost heterogeneity, especially of the natural covers, which is due to an increased representation of areas for grassland. Furthermore, I was able to find that the level of fragmentation of native forests has increased significantly. Finally, the greatest net change over period studied was the trajectory from native forest to arborescent shrubland. With these results,

it is expected to contribute to the understanding of Patagon landscape dynamics and guide decision making for territory planning.

Keywords: *Forest fires, landscape ecology, landscape metrics, Patagonian.*

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MEGAFIRES IN SOUTH-CENTRAL CHILE: A GEOGRAPHICAL ANALYSIS USING GOOGLE EARTH ENGINE

Vannia Ruiz Barrientos* and Francisco De la Barrera

Extensive wildfires are natural phenomenon in many parts of the world. For Mediterranean regions they represent serious environmental hazards, causing severe economic and environmental damages and life losses. Because of climate change, there is a growing awareness of megafire risks. It is expected increases in the ecosystems susceptibility to wildfires, frequency of fires, higher intensities and duration. In Chile, 99% of the wildfires are directly or indirectly human induced. The occurrence of forest wildfires in Chilean landscapes has increased strongly in the last decades. At a national scale the frequency of these events are approximately about 5000 fires per year, affecting 5000 hectares per year. However, the last megafire occurred in the mid-summer of 2017 in the area comprised by the regions locate between Valparaiso and Biobio (32°S – 70°W and 36°S – 73°W) affected 530,000 hectares, including native forests, forestry plantations, shrublands and grasslands. Thanks to the advances of remote sensing technique, it has been possible to realize historical studies regarding the fires that occurred in previous years. This work presents an analysis conducted on Google Earth Engine Platform and complementary software to quantify the extension of wildfire in the last two decades for South-Central Chile, identifying the extension and location of megafires. To identify the burned areas, NDVI and NBR indices were used. Results show the increase in the extension of megafires and diversity of locations of them. The megafires of 2017 were massively larger than previous fire because the extension comprised but also but the severity of fires. The methodology used is highly replicable and can be used for rapid monitoring of megafires in large study areas.

Keywords: *Wildfires, remote sensing, central Chile.*

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FOREST BIOMASS REDUCTION DUE TO ESCAPED SAVANNA FIRES: GALLERY FORESTS OF THE ORINOCO AT RISK

M. Meza-Elizalde*, J. Velez, D. Armenteras and T. Gonzales

The savanna region in northern South America is shared between Colombia and Venezuela and is a region where fire has been present for centuries as a natural fact but nowadays is often used for management purposes. These fires were meant to be a pasture management practice that under current climate change conditions is causing further disturbances to the tropical forests embedded in these savanna landscapes. Fires area affecting forests that were previously reported as barriers for fires in terms of structural changes, tree mortality and thus biomass and C depletion. Fires are

enhanced under certain climatic conditions. In Colombia, gallery or riparian forests in the Orinoco basin extend up to almost 2 million ha. We studied the area burnt with the MODIS burnt area product for the region between 2001 and 2015 and quantified the forest affected by fire. At least 203.808 ha of forest were affected by one fire in the 14 years period, followed by 35570 ha of forest that at least were affected twice and almost 10.000ha affected 3 or more times in the same period. Field sampling in the region provided us with some preliminary differences of up to 100tn/ha of total biomass between forests burnt and unburnt. Here we present the first quantification of the extent and measurement of biodiversity changes and biomass loss due to the effect of fire on riparian forests for this region.

Keywords: *Forest fire, forest degradation, biomass, monitoring biodiversity.*

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DEGRADATION OF OAK FOREST (*QUERCUS HUMBOLDTII*) CAUSED BY FIRE IN VILLA DE LEYVA - BOYACÁ, COLOMBIA

Natalia Salazar Latorre*, María Constanza Meza Elizalde,
Omar Felipe Chaparro Saavedra and Dolores Armenteras Pascual

The use of fire is a common practice of agricultural management for the elimination of biomass in recently cleared areas and for the maintenance of pastures. During years with high temperatures and severe dry seasons, risk increases, transforming fires into bigger uncontrolled fires that affect the regional climate and damage the functioning of ecosystems and their biodiversity. In Colombia, around 400,000 hectares are annually burnt, also affecting natural ecosystems. Existing management and control mechanisms implemented to mitigate these disturbances are limited, as well as knowledge about the effects that burning has on vegetation. The Andean forests of Colombia are not exempt of anthropogenic pressures and there has been an increase in the incidence of fires. This is the first study analyzing the degradation of oak forests (*Quercus humboldtii*) by fires in Colombia. From a sampling of 10 plots of 0.1 ha, the methodology consisted of: i) analyzing the changes in the structure and composition of oak forests, ii) estimating the differences in above ground biomass and, iii) determining the variation in the regrowth of oak in forests affected by fire. The results obtained showed that although the last fire in that area was in 2015, the fire negatively affected forest structure by eliminating a large proportion of trees, and damaged its composition by converting the forest into a less diverse community. The above ground biomass decreased in the forests affected by fire, in contrast to the unaffected ones and oak regrowth was considerably restricted after a burning event. Knowledge of post-fire dynamics is essential to identify the resistance and resilience of these climate change vulnerable ecosystems.

Keywords: *Biomass, structure, composition, oak regrowth, ecology.*

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Topic 4

**SOCIO-ECOLOGICAL APPROACHES
INTEGRATING ECOSYSTEM SERVICES
AND FOREST MANAGEMENT**

S 4.1

Mapping and assessment of ecosystems and their services: operational support towards scenarios for management

Chairs: Sandra Luque and Marine Elbakidze

MULTI-SCALE APPROACH TO ASSESS FORESTED LANDSCAPES ECOSYSTEM SERVICES AND TRADE-OFFS IN MULTIFUNCTIONAL SYSTEMS

Sandra Luque*

Forests cover more than one third of the total land area of the European Union. They represent a key natural resource, which has been managed for decades to meet growing societal demands for diverse forest ecosystem goods and services. Forest ecosystem services (ES), which are the benefits that humankind obtains from forests both directly and indirectly, are essential not only at regional levels but also at national and global scales (MA, 2005). The incorporation of the ES concept into the framework of forest management stems from a need to create a more holistic perception of forests, recognizing not only their economic value, but also their cultural and ecological values. Yet, despite improved understanding of the potential of landscapes and their land use systems to provide human well-being and socio-economic benefits, further conceptual and empirical work is needed to translate the concepts into operational frameworks for integrating ES into management and decision-making. Sustainable ecosystem management and well-being can be enriched with local people perceptions. Consequently, we need innovative methods that do not only facilitate shared understanding of the human-landscape relationships, but also foster collective management that can be incorporated into landscape planning processes. Likewise, when planning for ecosystem services, bundles of benefits need to be incorporated within adaptive forest management. Thus, optimization of the provision of a single service leads to reductions or losses of other services. Within these challenges in mind, different operational methods will be summarized and presented based on real cases experiences gained within the EU project OpenNess. Spatially explicit approaches provided different alternatives for policy makers in order to help targeting conservation priorities, cultural related services and production management options. Merging different models and developing multidisciplinary frameworks would improve our understanding of socio-ecological systems promoting means for efficient and effective utilization of sustainable forest management.

Keywords: *Cultural services, conservation targets, Spatial Bayesian Belief Networks, trade-offs, multifunctional landscapes, spatial planning.*

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FOREST CHANGE DETECTION TECHNIQUES BY TIME SERIES AND CROSS CORRELATION ANALYSIS

Cristina Tarantino, Maria Adamo, Saverio Vicario, Richard Lucas and Palma Blonda*

Forest management and validation of policies adopted can be supported by regular monitoring of changes and trends. Time series analysis of free Landsat and new Sentinel-2 ESA images can provide, on the one hand, an unique opportunity to detect changes in forest extent over time and trends. On the other, it can monitor ecosystems functioning through the detection of changes in specific essential variables, such as Gross Primary Productivity (GPP). Depending on users' requirements, in terms of computational efforts, the Cross Correlation Analysis technique could be used to detect changes between the forest layer extracted from an existing Land Cover (LC) map at T1 and a recent single T2 image. Available core services, such as the High Resolution

European Forest Copernicus layer (dated 2012) and other global scale LC maps (e.g., the University of Maryland LC maps, GlobeLand30) could be used as T1.

In this study, we discuss the change detection results obtained by both time series analysis and CCA techniques in protected areas characterized by different (i.e., high or very low) forest coverage. The dynamics of GPP from image time series using different vegetation indices (i.e., NDVI, MSAVI, EVI, SAVI) as proxy are also provided. Parametric and non-parametric approaches were applied to deal with missing or poor quality data. The possibility to monitor forest extent and forest functioning from the same time series may allow to characterize the type and source (driver) of changes.

The research work has been carried out within the Horizon2020 ECOPOTENTIAL project, focusing on ecosystem and ecosystem services monitoring. Within this project, the different change detection techniques have been integrated in the Earth Observation System for Ecosystem Monitoring (EODESM).

Keywords: *Change detection, time series, GPP, Copernicus layer.*

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SPATIAL ANALYSIS OF THE CARBON STOCK IN AERIAL BIOMASS OF THE MBARACAYU FOREST BIOSPHERE RESERVE, DEPARTMENT OF CANINDEYU, PARAGUAY

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Laura Rodríguez Yakisich and Victoria Rika Kubota

The research was performed in the Mbaracayu Forest Biosphere Reserve where four ecosystem services were analyzed through two ecosystem functions. The general objective was to analyze spatially the storage of carbon in aerial biomass and the protection of aquifers by vegetation cover in the Mbaracayu Forest Biosphere Reserve and its relationship with ecosystem services and the benefits they offer. On this poster we review the function of carbon storage only. For the study the variable was the storage of C in aerial biomass which was studied through the ECOSER tool; being the first investigation in Paraguay that uses it. This tool is based on the spatial analysis of the carbon storage ecosystem function offered by the different land cover, relating them to the climate regulation ecosystem service. The results were distribution maps of the climate regulation ecosystem service and the carbon storage function service. The maps resulting from the research demonstrate the importance of natural coverage in the provision of this service. Among the coverages, the relevance of the forests is highlighted, offering a greater provision of the ecosystem function under study and the ecosystem service. This study represents the opening of a new research line that allows the spatial analysis of an area based on its ecological attributes, which helps in the planning of an area.

Keywords: *Carbon storage, BAAPA, ECOSER, ecosystem function, aquifer vulnerability, GIS.*

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DRIVERS OF CHANGE IN FORESTRY AND AGRICULTURE IN EUROPE AND CENTRAL ASIA: OUTCOMES OF A IPBES REGIONAL ASSESSMENT

Marine Elbakidze* and Lucas Dawson

Managing trade-offs between an increasing global demand for food and materials and biodiversity conservation as a foundation for the delivery of diverse ecosystem services is recognized as a major policy challenge in Europe and Central Asia. Despite a variety of policy tools and environmental measures, conventional intensive agriculture and forestry is jeopardizing sustainable land management, including biodiversity conservation and food production. Applying a comprehensive literature review and qualitative systems modeling methods we analysed drivers of change in agriculture and forestry in Europe and Central Asia and their effects on biodiversity and ecosystem services. We mapped the dynamic inter-relationships within and between indirect and direct drivers using causal loop diagrams. Our assessment identifies the major pathways by which dominant trends in conventional agriculture and forestry impact on biodiversity and the sustainable provision of ecosystem services.

The review shows that despite the development of more sustainable land use policies and practices in the region, the major trend is increasing intensity of conventional agriculture and forestry, leading to biodiversity decline. This trend is underpinned by a wide range of institutional, economic, socio-cultural, technological, and demographic drivers. Our findings indicate structural similarity regarding the inter-relationships between indirect drivers of change in agriculture and forestry across the region. At the same time, the specific configurations of drivers and their causal influence on biodiversity and ecosystem services remain context specific. Directing outcomes in such a complex, dynamic system remains a difficult task for policy-makers. A mix of governance options, policies and management practices is available for public, private and civil society actors. However, in order to safeguard biodiversity and the sustainable provision of ecosystem services, further commitment is required to adopt and implement a holistic approach, which explores and assesses the efficacy of policy options in terms of the complex feedback structures between drivers of change.

Keywords: *Driver, intensification, policy option.*

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IMPACT OF LAND USE AND LAND COVER CHANGE IN THE SPATIAL ASSESSMENT OF ECOSYSTEM SERVICES IN PHEWA WATERSHED, NEPAL

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Community-managed forested landscapes are complex social-ecological systems that supply a variety of ecosystem services (ES) to society. The flow of these services depends on land use and land cover (LULC) patterns, composition and vegetation types and spatiotemporal changes. ES assessment helps to deal with the complexity of interrelationship between LULC, ES supply and societal benefits. Using a case of Phewa watershed, Nepal, this paper carries out a quantitative and qualitative appraisal of priority ES to understand how the supply of ES and their societal benefits have changed over the past 40 years. The LULC change was analysed using satellite images, ES were assessed using biophysical data and expressed spatially using ArcGIS. Results

indicate that significant changes in LULC had a positive impact on ES due to the conversion of agricultural/grasslands and degraded forests to dense forests. Maps show that ES varied significantly across the watershed. Dense forests provided relatively higher volumes of sediment retention, carbon stocks, biodiversity maintenance, and raw materials but reduced the water discharge over the last four decades. Increased aesthetic value from the restored landscape provides higher opportunities for recreation and ecotourism. Analysis of benefits using relevant indicators reveals that the wider societal benefits of most of ES were significantly lower compared to the supply of respective ES in the watershed.

Keywords: *Community forestry, ecosystem services assessment, sediment retention, biophysical approach, benefits relevant indicators.*

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MAPPING AND ASSESSMENT OF ECOSYSTEMS AND THEIR SERVICES: OPERATIONAL SUPPORT TOWARDS SCENARIOS FOR MANAGEMENT

Christine Fürst*

The mapping, assessment, monitoring and management of the quality of ecosystems and their capacities to contribute to ecosystem services provision is one of the most compelling and highly challenging demands arising from international science-policy processes such as IPBES (Intergovernmental Panel for Biodiversity and Ecosystem Services) or – in a more regional context – from the European Biodiversity Strategy, Action 5 (and related actions 6 and 7). An important issue in this field is to get a deeper insight into the impact of (forest) land management strategies that could intervene into some key services, such as regulating (climate, water), provisioning (timber, by-products) and cultural (recreation) services at least for limited time. So far, data considering intra-annual, operational and strategic management are not really well recorded and only few approaches exist to document management between typical reporting periods such as inventory or reporting to (CAP) funding agencies. As the data access situation cannot really be expected to be improved, scenarios that describe potential management interventions starting from a known period and prescribing alternative management interventions taken from surveys of local agents (land owners / land users) including aspects of unforeseen events can help to assess spatially more or less explicit and specifically over time how the services groups could be impacted. The talk summarizes experiences that were gained in connecting forest data with spatial LULCC modelling and will introduce examples how scenarios can be used to improve a knowledge-based decision basis for connecting better forest with (regional) spatial planning.

Keywords: *Ecosystem services, LULCC scenarios, land management strategies, IPBES.*

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USE OF ECOSYSTEM SERVICES CONCEPT IN ECOLOGICAL RESTORATION: LESSONS FROM TEMPERATE AND TROPICAL DRY FORESTS

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James D. A. Millington and Mark Mulligan

Ecological restoration has been gaining momentum worldwide over the recent years. As it grows in importance, it expands in scope and scale. At the same time with the increasing complexity and diversity of motivation, the question why we undertake a restoration becomes more important. As well, to find out whether any restoration activities accomplished the selected goals, their evaluation must closely match the restoration objectives. Ecosystem services provide a useful framework for planning as well as assessment of outcomes to link back to the restoration goals. We use spatial analysis and modeling tools to assess provision of ecosystem services from forest ecosystems that were restored, and project potential future ecosystem services provision under different restoration scenarios. We compare case studies in mixed temperate forests in the UK and tropical dry forests in Colombia, to ascertain whether such approach can provide robust quantification of gains, trade-offs, and point out critical factors in the determination of the ecosystems services flow, as well as in the decision-making process. We reviewed the objectives and priorities of the restoration projects, and selected the ecosystem services in line with these priorities, focusing on water provision, carbon sequestration, tourism and habitat provision, that represent all three categories of the ecosystem services: provisioning, regulating, and cultural. We show that ES concept is useful in three distinct stages of ecological restoration process. It provides a suitable platform to engage different stakeholders, and to get them on board in restoration project. It aids in prioritizing locations and showing future effects of different scenarios. It is also useful in assessment and quantification of whether and how well have the projects delivered on specific objectives.

Keywords: *Restoration, ecosystem services, modeling tools, temperate forests, tropical dry forests.*

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LANDSCAPE MONITORING OF SPANISH FORESTS FROM 1956 TO 2018: UPDATED RESULTS COMING OUT FROM THE 5TH SISPAIRES SURVEY

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Marta Ortega-Quero and Ramón Elena-Rosselló

SISPAIRES (Spanish Rural Landscapes Monitoring System), was initially developed in 1993 by photo interpretation (PI) of black & white aerial images from two nationwide surveys made in 1956 and 1984. Afterwards, SISPAIRES added two air photo surveys from 1998 and 2008. According to the experience from these last two surveys, a 10 years period is an appropriate interval for monitoring agrarian, including forested, landscapes in Spain. Therefore, 2018 is the year for the next SISPAIRES survey. Currently, the 5th SISPAIRES survey is being conducted. For the first time, we are using Sentinel remotely sensed data, which can be downloaded just one week after its recording. This fast availability of satellite imagery allows to carry out within the same year the acquisition of the images together with the PI and the GIS data production and analysis. SISPAIRES is based on geodata periodically recorded in REDPARES: A permanent landscapes network composed of 215 squares of 4x4 km. These landscapes were selected through stratified sampling by using CLATERES, the Spanish Bio-geo-climatic Land Classification.

Landscape information has been growing up with data recorded in 5 dates (1956, 1984, 1998, 2008 & 2018) providing a powerful and cost-effective tool for tracking land cover changes at the national scale. In our presentation, recently updated data will be showed, including relevant information about the forest landscapes structural and functional features. Preliminary data suggest that polarization of landscapes detected in previous periods has increased through both the urbanization and agricultural intensification processes in the most active regions, and the rural abandonment in the poorer ones. Another fast growing impacts in forest landscapes have been the development of renewable energy parks widespread all over Spain, including wind and solar parks. Furthermore, high-speed railways and motorways, as well as wildfires in agro-forest and urban-forest interfaces, also seem to have impacted them.

Keywords: *Landscape dynamics, land use change, landscape metrics.*

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SISPARES 2018: UPDATED ASSESSMENT OF PASSIVE RESTORATION AFTER ABANDONMENT AND SUBSEQUENT CHANGES OF LAND USES IN SPAIN SINCE 1956

César López-Leiva*, Sergio González-Ávila,
Ramón Elena-Rosselló and Marta Ortega-Quero

Land use has changed abruptly throughout rural Spain over the last 70 years. The abandonment of agricultural lands was driven by the emigration into urban areas and the subsequent decrease of crops and pastures. The key trend of this phenomenon, which may be considered a ‘natural disturbance’, is the succession to emerging scrublands or even the direct shift to woodlands, which converge with active restoration (reforestations). Opportunities of this dynamical framework include the passive restoration, providing ecosystem services such as the increase of ecological network function and connectivity, biodiversity, water regulation and soil recovery, albeit other negative effects may arise (i.e., wildfire risks). This paper explores the role of abandonment in landscape dynamics during 1956-2018, based on the recently (2018) updated Rural Landscapes Monitoring System SISPARES (1956, 1984, 1998, 2008). We present an overview of the spatial evaluation of this process in environmental stratified samples, emphasizing the changes patterns and flows and their magnitudes. In the last SISPARES period (2008-2018) expansion and densification of spontaneous plant covers continued. We aim to estimate if configuration shifts are also evident and if the composition of the mosaic fragments of scrublands and forests corresponds to the widespread decline of prior croplands. These dynamic traits seem to have reached a state of general stabilization since 2008, after the extended abandonments from the 60s until the 90s. The assessment of dynamic indicators, as conceived by SISPARES, provides a useful tool for the evaluation of the extent and location of transforming landscapes. SISPARES 2018 reveals an intensification of changes. From now, the overview can be broadened encompassing the entire available period since 1956. Whilst socio-economic conditions and policies in rural areas remain, trends of ecological responses will follow the same trajectories.

Keywords: *Landscape monitoring, landscape dynamics, revegetation.*

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CORRELATION BETWEEN WATERSHED ECOLOGICAL VULNERABILITY AND ECOSYSTEM SERVICES: A CASE STUDY OF BAILONGJIANG WATERSHED IN SOUTHERN GANSU

Jie Gong*

Based on SRP model, Analytic Hierarchy Process and InVEST model, Bailongjiang Watershed (BLJW) in southern Gansu is selected as a case to carry out ecosystem service mapping, ecological vulnerability mapping and its relationship. The ecological vulnerability in BLJW can be divided into five levels: slight vulnerability, light vulnerability, moderate vulnerability, severe vulnerability, extreme vulnerability. The main conclusions are: (1) the proportion of medium vulnerability regions is relatively large from 1990 to 2014a, and the extreme and severe vulnerability regions are concentrated in the both sides of Baishui jiang, Bailongjiang and the tributary of Datuanyu River. (2) As to the typical ecosystem services, Wudu District has the largest crop production capacity, followed by Tanchang, Wen County, Zhouqu and Diebu. As to the spatial distribution pattern of ecosystem services, the spatial distribution of water production and carbon storage in BLJW is similar of which the high-value areas are both mainly concentrated in southern Tanchang and southern Baishuijiang. The area distribution of soil conservation and high habitat quality is similar as the high-value areas are mainly distributed in the agroforestry and nature reserves areas. (3) In addition to being positively related to crop production, there is a significant negative correlation between ecological vulnerability and carbon storage, water production, soil conservation service and habitat quality, respectively. Meanwhile, the correlation between ecological vulnerability and integrated ecosystem services under ecosystem services equilibrium scenario and ecological protection priority scenario are negative correction. (4) Based on the analysis of ecosystem services and ecological vulnerability of the ecological protection scenario, BLJW can be divided into four zones with consideration of natural and human factors, Comprehensive Development Zone, Key Forestry Protected Zone, Intensive Agricultural Production Zone, and Ecological Protection and Recovery Zone. Some suggestions are put forward for watershed ecosystem governance and its sustainable development.

Keywords: *Ecological vulnerability, ecosystem services, correlation, watershed ecosystem management.*

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CAN INVEST-HABITAT QUALITY MODEL WITH LANDSCAPE PATTERN INDEX USEFUL TO DETECT AND MAP MOUNTAIN BIODIVERSITY CHANGE

Jie Gong*

Chinese mountains hosted very rich biodiversity, were home to million people and inhabitant with vital ecosystem service, had experienced the most serious biodiversity loss with fragile environmental problems. Even though increasing attentions had been brought to this issue, we still lacked methods to assess change of biodiversity change in medium/large scale due to data-poor and multiple habitat types co-exist. This study proposed an integrated method with InVEST-habitat quality model, NPP and landscape index to analyze the spatial heterogeneity of biodiversity and its spatiotemporal change on the raster cell scale. The results indicated that biodiversity service was higher and had obvious spatial pattern variations in BLJW. The land area containing higher biodiversity accounted for 39.8% of the total watershed area, which mainly

distributed in the National Nature Reserve and forestry area. While the area with lower biodiversity mainly distributed in the valleys between Zhouqu-Wudu-Wen County, the valley of Minjiang in Tanchang County, alpine mountain snow regions. During 1990-2010a, biodiversity tended to increase and the higher biodiversity area increased from 7.96% to 13.27% due to ecological restoration and forestation, while biodiversity decreased in the area with intensive human activities, such as cultivated land, urban and rural land. The results also showed that combining InVEST-habitat quality model, NPP and landscape pattern index could detect and reveal mountain biodiversity change objectively. The study was useful for biodiversity conservation policy-making and human activity governance for the disaster-impacted mountainous areas in China.

Keywords: *Spatial change, habitat quality, landscape pattern, biodiversity conservation, InVEST model.*

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INNOVATIVE APPROACHES FOR FOREST STEWARDSHIPS AT LANDSCAPE SCALE

Kalev Sepp*, Siiri Külm, Are Kaasik, Miguel Villoslada and Janar Raet

Over the past forty years, the forest coverage of Estonia has increased by 10% and, today, about half (50.6%) of Estonian mainland is covered by forest. The economic and ecological vitality and sustainability of forests can significantly be affected by the timely implementation of forest management practices. Currently, the most common harvesting method in Estonia is clear-cutting, which is used in more than 90% of the cases. Such extensive use of clear-cutting has led to conflicts in many parts of Estonia, especially nearby settlements. To ensure sustainable and environmental friendly forest management, to prevent different conflict situations, to improve landscape quality in terms of ecosystem services, it is necessary to evaluate different possible impacts of clearcutting on ecosystem services and measures for making alternative forest management decisions, concentrating especially on national forest areas. Analyses show that one of the main problems is the use of clear-cutting in the vicinity of densely populated areas, which results in the decrease of public goods such as beautiful scenery and recreational opportunities granted by the existence of forests. Also, forest management derived by economical principles (clear-cutting is less expensive and more profitable than other forest management methods) and the lack of co-operation and deficiency of sharing information between different parties are some factors that cause conflicts. Based on the analyses worked out governance mechanisms are orientated to decrease and prevent negative aspects of forest management on ecosystem services at the landscape scale. Ecological, socio-economical and cultural factors were defined to identify possible forest areas where clear-cutting might lead to conflicts. New governance mechanism for forest management related to ecosystem services was proposed (a compensation mechanism for restrictions on the use of clearcutting, landscape planning in the forest) and implemented in Harju County.

Keywords: *Ecosystem services, governance, public involvement.*

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MAPBIOMAS PROYECT: SYSTEMATIC LAND USE AND COVER MAPPING FOR THE GRAN CHACO AMERICANO. FIRST OUTPUTS, 2010–2017

Santiago Veron*, Diego de Abelleira, Santiago Banchemo, Hernán Elena, Juan Gaitán, Fabiana Arévalos, Mayra Milkovic and José Volante

Accurate and reliable information on the dynamics of land use is key for environmental monitoring, natural resources management and territorial planning. Historically, our ability to produce maps with efficient and accurate operative routines has been limited by the availability of satellite imagery and processing capacity. The MAPBIOMAS project is an initiative that involves a collaborative network of biomes, land use, remote sensing, GIS and computer science experts that rely on Google Earth Engine platform and its cloud processing and automated classifiers capabilities to generate Brazil's and Gran Chaco annual land use and land cover time series. For the Gran Chaco Americano, the study area was divided into 94 cells of 1° x 1.5°, which represents an area of 1,522,800 km². Eight classes were defined following the criteria of the LCSS-FAO Land Cover Classification System: natural woody vegetation, natural herbaceous vegetation, dispersed natural vegetation, cropland, pastures, bare areas and water. We used 84 spectral indices based on LANDSAT TM, ETM and OLI, images and the Random Forest machine learning algorithm available on the Google Earth Engine platform. More than 10,000 training samples were generated through the visual interpretation of LANDSAT and Google Earth images and using MODIS time series. In this stage, the results obtained focus on the annual maps of land use/cover between 2010 and 2017. This task was carried out in a distributed way among several interpreters with expert knowledge of the territory. The methodology of decentralized work and technology available in the cloud has made possible the systematic landscape-scale mapping of the Gran Chaco Americano. The main contributions of this work are methodological aspects of sample collection and in the generation and validation of a digital cartography of extended territory at 30 m spatial resolution.

Keywords: *Feature scenarios, ecosystems services.*

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THE POTENTIAL IMPACT OF ECONOMIC POLICIES ON FUTURE LAND-USE CONVERSIONS IN ARGENTINA

M. Piquer-Rodríguez*, M. Baumann, V. Butsic; I. Gasparri, G. Gavier-Pizarro
J. N. Volante, D. Müller and T. Kuemmerle

Agricultural expansion and intensification drive the loss of ecosystems worldwide. Scenarios are powerful tools to explore future changes in land-use patterns and their effect on ecosystems and the services they bring to society. Focusing on Argentina's prime agricultural areas, the Pampas, Espinal and Chaco, we developed spatially-explicit future land-use scenarios from 2010 to 2030, considering both agricultural expansion (i.e., conversions from woodland to either grazing land/grasslands or cropland) and agricultural intensification (i.e., conversions from grazing land/grasslands to cropland). Our simulations were based on an econometric model of net returns, allowing us to assess the amount and spatial patterns of future land-use change under current zoning (i.e., the so-called Forest Law) in our study region. We systematically tested the impact of economic policies (e.g., taxes or subsidies), infrastructure improvement (e.g., road paving), and technological innovation (i.e., yield increases) on the spatial patterns of land-use conversions and on the remaining woody and grasslands ecosystems. We also evaluated which priority areas for conservation would undergo land conversions under all scenarios. Assuming land-conversions continue at 2000-2010 rates, resulted in continued expansion of cattle ranching into woodlands in the western Chaco, and of cropland in both in the western and eastern Chaco, whereas intensification dominated in the southern Chaco and in the Pampas. Economic policies affected

expansion rates of ranching in the Chaco markedly. Improving the region's road network would create a strong incentive to expand cropland further into remaining woodlands and over grazing lands. Given that our study also highlights the continued land conversion pressure under all scenarios on the region's remaining natural areas, zoning, if properly enforced, appears to be a more straightforward tool for avoiding unwanted ecosystem impacts in the Chaco. Overall, our study provides insights into how alternative economic policies might change land-conversion patterns affecting regional ecosystems and the services they provide.

Keywords: *Cropland; grazing land; woodland; deforestation; Chaco; Espinal; Pampa; conservation sites; zoning.*

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CAN ECOSYSTEM SERVICES BE AGENTS?

Ulfa A. Lenfers*

How do different human groups act and interact in the same social-ecological system? Multi-agent modelling and simulation (MAMS) can help to find out. A key element of human modelling is how agents plan their behaviour. Goal-oriented action planning (GOAP) allows agents to adapt their behaviour in relation to their own setup, personal traits and the different goals they try to fulfil. GOAP was originally developed by game developers years ago. Additionally, simulating large numbers of agents with complex behaviour demands specialized algorithms and frameworks. The massive multi-agent modelling and simulation framework MARS is under development at Hamburg University of Applied Sciences, Germany. It provides a mechanism to bridge spatial scales from the individual level up to landscapes or even entire countries. To overcome the problem of the static and sometimes non-authentic behaviour of agents we integrated GOAP into MARS. As a proof-of-concept, a firewood collection scenario was developed. In here, competing demands for land use around villages were analysed by simulation runs. Beside human agents, e.g. firewood collectors, we modelled ecosystem services in the landscape by agents also. By that, temporal changes of service provisioning could be easily described. First results show that GOAP is a suitable paradigm for modelling complex and adaptive behaviour in MAMS scenarios. Describing ecosystem services by agents obviously raises the need for large-scale multi-agent modelling and simulation frameworks. MARS can be seen as a proper step in this direction. Our results will form the foundation for a web-based decision-support information system for environmental management in regions with high social-ecological influences like, for example, the Kruger to Canyon (K2C) Biosphere in South Africa.

Keywords: *Multi-agent simulation, goal oriented action planning (GOAP), ecosystem services, firewood collection.*

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SPATIAL DYNAMICS OF COMMUNITY LANDSCAPE SERVICE VALUES ACROSS THE SOUTH WEST MAU FOREST, KENYA

Ethan F. Miller*

Increasingly, resource managers are seeking to conserve forests for the landscape services they provide. This is especially true in the Mau Forest of Kenya where national and international attention has focused on preserving watershed services and livelihoods through forest conservation. Understanding what drives people to value landscape services where they do is critical for crafting policies that reflect peoples' needs and perspectives. This research analyzes the drivers of the geography of landscape service value through a case study of two communities—Kedowa and Kuresoi—within the South West Mau Forest of Kenya. The study utilized a mixed-methods approach in which participatory mapping and spatial statistics were performed to map the distribution of values for individual landscape services and then semi-structured interviews were analyzed to distill themes that explain the spatial distribution of these values. In total, 55 village residents were interviewed across the two communities; the sample was disaggregated by gender and age. The most-commonly listed landscape services were water, firewood, farming, grazing, timber, and medicine and values for these services were distributed across the forest and village land and vary over time. Interview analysis revealed that four main factors determined the locations from where these services were derived: land use history and tenure, social relations, market access, and biophysical conditions. These drivers affect the geography of value for landscape services differently based on the service and community in question. This study demonstrates that people in nearby communities can use and value the same services in dramatically different ways and that the spatial distributions of these services stem largely from a few overarching drivers. Understanding this heterogeneity can lead policymakers and managers to create forest plans that are adaptive to local contexts and account for temporal and spatial dynamics of value.

Keywords: *Ecosystem services, participatory mapping, landscape service value, participatory rural appraisal.*

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Miombo Network of southern Africa: a research alliance to support sustainable management of Miombo Woodlands

Chairs: Natasha Ribeiro, Sally Archibald, Judith Kamoto,
Stephen Syanpungani and Alfian Rija

SUSTAINABLE WOOD HARVESTING IN THE MIOMBO WOODLAND THROUGH IMPROVED SILVICULTURAL SYSTEMS

Stephen Syampungani*, Natasha Ribeiro, Sally Archibald and Casey Ryan

The paper focuses on the need to balance the need of different users against the regeneration ecology and growth of the resource base for miombo woodland of Southern Africa. It draws on the importance of understanding the effects of harvesting for woodland and related products on the composition and structure of residual stand. It further discusses Miombo as vegetation formation whose dominant species require maximum light for regeneration. As such, the paper explains the importance of the major disturbance factors in Miombo woodlands such as charcoal production and shifting cultivation in supporting the regeneration of dominant species and therefore Miombo ecosystem as a whole. Regeneration mechanisms (such as seed, coppicing and root suckering) enables the recovery of Miombo woodlands. Based on this information, the paper recommends how various regeneration mechanisms and the characteristics of the dominant species may be incorporated in developing silvicultural system and prescriptions that provides for sustainable woodland management. It also concludes by suggesting application of management systems that provide for a diverse range of uses and values.

Keywords: *Disturbance, regeneration, silvicultural system & recovery.*

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COMMUNITY BASED NATURAL RESOURCE MANAGEMENT AND THE NEGLECT OF LOCAL INSTITUTIONS IN POLICY DEVELOPMENT

Judith Kamoto*

Approaches to natural resource management emphasize the importance of involving local people and institutions in order to build capacity, limit costs, and achieve environmental sustainability. Governments worldwide, often encouraged by international donors, have formulated devolution policies and legal instruments that provide an enabling environment for devolved natural resource management. However, implementation of these policies reveals serious challenges. This article explores the effects of limited involvement of local people and institutions in policy development and implementation. An in-depth study of the Forest Policy of Malawi and Village Forest Areas in the Lilongwe district provides an example of externally driven policy development, which seeks to promote local management of natural resources. The article argues that policy which has weak ownership by national government and does not adequately consider the complexity of local institutions, together with the effects of previous initiatives on them, can create a cumulative legacy through which destructive resource use practices and social conflict may be reinforced. In short, poorly developed and implemented community based natural resource management policies can do considerably more harm than good. Approaches are needed that enable the policy development process to embed an in-depth understanding of local institutions whilst incorporating flexibility to account for their location-specific nature. This demands further research on policy design to enable rigorous identification of positive and negative institutions and ex-ante exploration of the likely effects of different policy interventions.

Keywords: *Local institutions, social capital, elite capture, policy development, community based management, decentralization.*

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DIVERSIFIED USE OF FOREST RESOURCES VS CHARCOAL SPECIALIZATION: THE CASE OF COPPERBELT PROVINCE, ZAMBIA

Moses Kazungu*

Forests are renewable capital that significantly contributes to rural households' livelihoods, especially in the tropics. In the Copperbelt Province of Zambia, rural households seem to follow two distinct strategies related to the use of forest resources. One part of households have adopted a diversified forest resource use mainly for subsistence, while another part of households specializes in collecting wood to produce charcoal for cash income. The existence of two different strategies also indicates the importance of adjusting forest conservation policies to the needs and constraints of two distinct clusters of households. Using cross-sectional data of 207 households from two landscapes of restricted and non-restricted forests use, we seek to understand the influence of different socioeconomic factors on the decision of households to diversify in use of forest resource or to specialize in charcoal production. We first use a cluster analysis to group households according to their use of forest resources. Preliminary results show 19.8% of surveyed households specialize in collecting wood for charcoal production accounting for 42% of the time allocated to forest resources harvesting. Secondly, we estimate a multinomial logistic regression to assess the factors that influence the choice of a certain strategy. We account for the potential effect of various socioeconomic factors affecting households' behaviour, including socio-demographic characteristics, asset endowment, shocks and village-specific characteristics. Our preliminary findings from regression analysis indicate that household size, total asset endowment, and proximity to a market have a significant positive effect on household decision to specialize in charcoal production.

Keywords: *Forest resources, diversification, charcoal specialization, cluster analysis, multinomial logistic regression.*

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MIOMBO WOODLANDS A SOCIO-ECOLOGICAL ECOSYSTEM

Natasha Ribeiro*, Isla Grundy, Ana I. Ribeiro, J. Timberlake,
Francisco Maiato and Judith Kamoto

The miombo woodlands cover 2.7 million km² across seven countries (DRC, Angola, Zambia, Malawi, Zimbabwe, Tanzania, and Mozambique) in southern Africa. The socio-ecological relationships established in miombo are unique and are key to sustain the ecosystem and livelihoods in the region. Maintaining these relationships is a challenge in the current context of accelerated human population growth coupled with economic development, which imposes rapid land cover changes in miombo. In this communication, we analyze the capacity of the woodlands

to provide goods and services. We also analyze key challenges in maintaining ecosystem's capacity as well as issues of sustainable management.

Keywords: *Socio-ecology, miombo, disturbances, management.*

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ARE BUFFER ZONES USEFUL FOR THE CONSERVATION OF BIODIVERSITY IN MIOMBO WOODLANDS? THE CASE OF CHIMANIMANINR IN MOZAMBIQUE

Pekka Virtanen*

The concept of Buffer Zone (BZ), which refers to ‘a zone that is peripheral to a national park or reserve, where restrictions are placed upon resource use or special development measures are undertaken to enhance the conservation value of the area’, was popularized by the Protected landscapes approach in the early 1990s. However, the usefulness of the concept remains debated, as some claim that it has not contributed to the intended biodiversity conservation objective, while others criticise it for not having fulfilled the human rights and equity related objectives. In the paper I trace the evolution of the BZ of the Chimanimani NR in Mozambique, the participation of different stakeholders – in particular local communities – in its development, and its role in the protection of biodiversity of the region, which in the BZ consists mostly of semi-deciduous Miombo woodland. The NR was established in 2003, and consists of a core conservation area (645 km²) and a surrounding BZ (1723 km²). On the west it borders on Zimbabwe’s Chimanimani NP. Drawing on theory of practice, I examine the role of different actors in the definition of the borders of the NR and the permissible land-use practices, related conflicts over agricultural expansion and wildlife damage, and successes in promoting conservation agriculture and non-consumptive use of the Miombo woodlands. The paper is based on (i) the author’s interviews and participant observation when the NR project was initiated in 1998-2001 and a follow-up visit in 2015; (ii) fieldwork in the context of a capacity building/research project by a Finnish-Mozambican team (including the author) in 2018; (iii) project documents, progress reports, consultant reports and academic studies produced in the project context; and (iv) other relevant research literature.

Keywords: *Miombo, conservation of biodiversity, buffer zone, landscape approach.*

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BIODIVERSITY DYNAMICS OF MIOMBO SPECIES IN GORONGOSA: EFFECT OF FIRE, SOIL, TERMITES AND HUMAN PRESSURE

Camilo Antonio*

Miombo woodlands constitute the most important vegetation type of southern Africa, being predominantly consisting of Mimosoideae species of *Brachystegia*, *Julbernardia* and *Isoberlinia*. The burning is a tool for cultural management, which has been used by the majority of rural communities in the region of miombo. It is also a key ecological factor in the maintenance of miombo woodland ecology. However, changes in fire regimes derived, among others, human

population growth and climate change, may affect the ecology of the miombo. was conducted the work which had objectives contribute to the biodiversity conservation program of miombo in Gorongosa through the study of molecular characterization and determination of diversity of *Brachystegia spiciformis* and *Brachystegia boehmii*, survey fitossociológico. Sampling was done in plots of 100 m x 100 m in 7 parcels, on which were counted all individuals and collected only 10 samples of fresh leaves of *Brachystegia spiciformis*.and *b. boehmii*, were taken for molecular analysis. Were numbered 966 individuals distributed by 3 families, with 16 species sampled in the survey fitossociológico. Most of them are typical miombo woodland, the species of *Brachystegia boehmii* was the species with larger ecological importance where your IVI was 42.24883 and the least important was *Azelia quanzensis* with 0.31366 Importance value index.

Keywords: *Miombo, importance value index, Gorongosa, physiognomy, vegetation.*

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Ecosystem services for forest
sustainable use governance:
a light beyond the tunnel?

Chairs: Graciela M. Rusch and Tobias Plieninger

ASSESSING THRESHOLDS IN ES CHANGE TO OPERATIONALIZE SUSTAINABLE USE GOALS: THE CASE OF THE NATIVE FOREST LAW IN ARGENTINA

Verónica Rusch*, Santiago Varela, Andrea Goijman and Graciela Rusch

In Argentina, the Forest Law (N° 26331 of “Minimum Standards of Environmental Protection of Native Forests”), enacted in 2007, aims to protect and promote the sustainable use of forest ecosystem services (ES). Ten criteria (six targeting native biodiversity, one soil and water protection, and two targeting production and one social objectives) were established for land zoning in three forest conservation categories. The use of Criteria and Indicators (C&I) for sustainable management at the local level is also proposed in the law, but has not yet been implemented, leaving much uncertainty about acceptable levels of use for each system. Earlier work has used Decision Support Systems (DSS) to analyse outcomes of silvopastoral use in ñire (*Nothofagus antarctica*) forest in northern Patagonia, showing that there are trade-offs between provisioning ES (i.e., forage vs. firewood), and between provision and maintenance and regulation services (i.e., forage vs biodiversity). In this study we further develop the DSS by specifying minimum standards that would maintain the system within desirable ranges, which may constrain management options to comply with the law. The model enables to visualize that logging activities of medium and high intensities are compatible with a > 50% probability of compliance with the Law, but the combination of logging and grazing is incompatible. Hence, management design including set-aside areas for conservation is critical to achieve Law objective at the farm level. Current knowledge and the set of C&I could be considered as a starting point. An estimation of farmer’s income and the determination of acceptable thresholds of relevant socioeconomic and environmental indicators could set levels and targets of the compensation schemes formulated in the Law. We suggest that economic compensation as delineated by the law to promote the sustainable use of ES, could be implemented to help landowners reach those standards.

Keywords: *Nothofagus* forests, silvopastoral, trade-off, environmental law.

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FOREST MULTI-FUNCTIONALITY AS A FRAMEWORK FOR CROSS-SECTORAL BROKERAGE

Graciela M. Rusch*, Hilde K. Wam, Jiska Van Dijk,
Paul E. Aspholm and Even Bergseng

BIONAUT is a network-building project of scientists and ecosystem services (ES) users for addressing challenges of multiple functions and values generated by forest in Norway. BIONAUT uses a case study of a peri-urban forest area that provides multiple recreational opportunities for city dwellers in Oslo, overlapping with areas of high biodiversity and cultural heritage value and forest production activities. A proposition of gazettement the area as a forest national park is under evaluation. Through a stakeholder participatory process, BIONAUT will identify and assess important ES currently generated by this forest area and evaluate possible changes in ES if the area becomes protected and the responses of the users to these changes.

We use an integrated ecosystem services valuation framework (Jacobs et al. 2016) to raise awareness about the challenges and opportunities of setting up protected areas in highly populated

areas; specifically: i) the use of the Cascade Model (Haines-Young & Potschin 2013) to structure the understanding of ES generation and their benefits; ii) a tiered approach to ES mapping according to the spatial scale of the geographical context (Grêy-Remaney et al. 2015); iii) tailoring the level of detail of ES data to policy instrument objectives (Gómez-Baggethun & Barton 2013); iv) raising awareness about the sources of uncertainty associated with ES assessments and mapping (Barton et al. 2018), and v) assessing the nature of the interactions among ES following the framework for understanding SDG interaction (Nilsson et al. 2015).

Keywords: *Ecosystem services change; science-policy; cross-sectoral; protected areas.*

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WOMEN AND FOREST GOVERNANCE IN HIMALAYA: INNOVATIVE PARTICIPATORY EXPERIMENTS FOR RESTORATION OF FOREST ECOSYSTEM SERVICES

Bhagwati Joshi* and Prakash C. Tiwari

In Himalaya, owing to constraints of subsistence farming large proportion of male-population out-migrates in search of livelihood leading to feminization of agriculture and resource development process. Women make implicit contribution towards subsistence economy through forming a range of institutions for sustainable development of natural resources. 'Forest Panchayats' (Village Forest Councils) of Himalaya are the oldest form of participatory institutions in the world constituted for forest governance. Forest Panchayats represent one of the largest and most diverse experiment in a localized form of community forestry in Himalaya. A large number of Van Panchayats are now headed and managed by women. Women headed Van Panchayats are now making innovative experiments not only in forest and resource conservation; but also in climate change adaptation, rural livelihood improvement and gender mainstreaming.

Study aims to analyze role, impact and effectiveness of women managed 'Forest Panchayats' in forest governance, and assess their contribution in reducing community-vulnerability to climate change through empirical study of 100 women headed 'Forest Panchayats' in Uttarakhand Himalaya. Results indicated forest cover increased between 7% and 15% during last three decades that not only increased groundwater recharge and improved water availability for both drinking and irrigation (15%); increased agricultural productivity (10%), improved livelihood opportunities in traditional agricultural and forestry sectors (25%). Regular income from forestry and farming sectors also reduced community-vulnerability to climate change induced risk of seasonal shifts in land-based livelihood (10%). Increased forest cover enhanced carbon sink by sequestering carbon at rate of 3.7 t/ha/yr. Thus, women managed Forest Panchayats have been successful in interlinking changing local needs, national development priorities and global

environmental concerns at local level. These innovative experiments may go long way in enhancing climate change adaptation capacity of communities by improving livelihood opportunities all across the mountains regions particularly in developing world.

Keywords: *Village Forest Councils, Traditional forest management institutions, rural livelihood improvement, groundwater recharge, climate change adaptation and mitigation.*

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SELECTIVE LOGGING OF WOOD IN NATIVE FOREST: ECONOMIC ANALYSIS

Ignacio Benito Amaro*, Patricia Egolf, Martin Pinazo and Luis Colcombet

The forest protection law, which was passed at the end of 2007 in Argentina, has brought about multiple discussions on economics incentives regarding to conservation on the part of private actors. One of the most passionate debate was given around the uses allowed by this regulation in the areas that were categorized under conservation degree II or yellow zone because it restrict the change in the use of the land. It is possible to quantify the land expected value (LEV) assigned to a sustainable manage of the forest with selective logging applying the formula of Fautsmann. This method makes possible to evaluate the optimal logging that maximizes the returns to the land based on the flow of commercialization of wood collected from the forest. Also, it lets to measure the willingness to pay agents for the land covered by forest mass whose productive use is the selective logging of native species from a sustainable manage. There are alternatives in the use of the land that offers better profits margins and added to this there are expectations about changes on the classification of the sites that leads us to propose the working hypothesis. It consist on, the market value or “commercial value” of the sites classified as conservation degree II is higher than the maximum discounted net value that would be obtained through the forestry use of native forest under a sustainable system of selective cutting. From the analysis proposed, we seek to test the hypothesis put forward, trying to understand how the incentives of the agents in relation to forest conservation are operating.

Keywords: *Fautsmann, Nativo forest, economics incentives.*

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FORESTS AND ECOSYSTEM SERVICES IN MIDDLE HIMALAYA: A FRAMEWORK FOR SUSTAINABLE RESOURCE UTILIZATION AND ENVIRONMENTAL GOVERNANCE

Prakash C. Tiwari* and Bhagwati Joshi

Natural forests in Himalaya carry large human population, including forest dependent indigenous communities living interspersed them. As a result, traditional resource utilization structure in Himalaya is closely interlinked with forests, farmland and livestock. These rural communities are completely dependent on forests-ecosystem not only for the fulfilment of their basic resource needs; but also for their livelihood. Recently, variety of changes have emerged in traditional forest utilization structure mainly in response to population growth, rapid urbanization, tourism development and economic globalization that eroded social value-system and disintegrated

indigenous forest management framework. Consequently, forest resources depleted steadily and significantly disrupting ecosystem services and threatening community livelihood.

In Himalaya, forests comprising of rangelands, grasslands and wetlands constitute headwaters of natural springs and streams. The depletion and degradation of forest resources is disrupting hydrological regime, diminishing water resources, and consequently increasing vulnerability of large population to water, food and livelihood insecurity. Paper interprets drivers of forest depletion and assess their impact on freshwater ecosystem, and evolve an improved community based forest governance framework with an empirical illustration of Ramgad Watershed, Kumaon Himalaya. Methodology included: (i) forest dynamics monitoring employing remote sensing techniques; (ii) hydrological observations and monitoring, and impacts assessment of forest depletion on freshwater ecosystem and food security; and (iii) evolving watershed based forest governance framework. Results indicated forest area constitutes nearly 51% of watershed area. Approximately 16% forest depleted and degraded during 1985-2015. These changes decreased forests, grassland and wetland respectively 3.04%, 3.34% and 1.67%; 37% springs and about 7 km stream-length dried, and stream-discharge decreased by 15%. Consequently, 74% villages are facing great scarcity of water, and watershed lost 16% irrigation potential declining 15% food productivity.

Keywords: *Land-use intensifications, freshwater ecosystem, remote sensing techniques, food security, participatory forest management.*

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EVALUATING COLLABORATIVE MANAGEMENT WITHIN THE NATIONAL PARKS AND WILDLIFE SANCTUARIES OF BANGLADESH

Md. Shams Uddin* and John Park

The protected area system of Bangladesh comprises 17 national parks covering 45,740 hectares and 21 wildlife sanctuaries covering 394,053 hectares (in March 2017). The Government of Bangladesh introduced collaborative management in these reserves in three successive, expanding phases undertaken between 2003 up until the present time. During this period, the successive programmes introduced an elaborate collaborative management system. This paper evaluates this collaborative management system as well as the protected area management arrangements being promoted, comprising: (i) the Co-management Council, (ii) the Co-management Committee, (iii) the People's Forum, and (iv) sub-village institutional bodies including the Community Patrol Groups and the Forest User Groups (or the Village Conservation Forums). It assesses the management interventions and the effectiveness of the collaborative management system to implement an effective protected area programme. The review indicates that the current organization and mandate of the protected area authorities precludes them from being effective partners in collaborative management, lacking dedicated staff in both the outreach and livelihood agendas, which severely undermines their participation in collaborative management. This paper recommends that the protected area authority needs to be strengthened

and reorganized, in order to play a leading role in village engagement – and a key leading agency in the higher level collaborative management bodies.

Keywords: *Bangladesh, co-management, collaborative management, national park, protected area, wildlife sanctuary.*

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LOCAL GOVERNANCE MECHANISMS AND SOCIAL NETWORK ANALYSIS: MODELING TO LEARN, PARTICIPATING TO DECIDE – LESSONS FROM MISIONES, ARGENTINA

Jonathan Von Below*

The loss of native forests imposes changes in the quality of the environment, in the way of life and in well-being of local populations, whose interactions affect the dynamics of the socio-ecological system (SES). These are multidimensional spaces where power relations are stratified and intertwined, and where social actors with similar or different interests may compete or collaborate to take control of natural capital and its ecosystem services (ES). This is due to the different types of social, political and economic capital that each actor possesses, and the different values they make of ecosystem benefits. Participatory modeling of SES is useful for decision making, since promoting social learning can help improve and democratize this process. Social actors with different levels of power and interest in natural capital use different governance mechanisms. Our aim for this work was to explore the capacity of participatory modeling of SES to promote social learning and governance mechanisms of vulnerable social actors. Ten focus groups were held in different municipalities from Misiones, Argentina (Puerto Piray, Colonia Delicia, Pozo Azul, Puerto Libertad) during 2016-2017. A categorical reconstruction was carried out based on the information from the focus groups. Statistical analysis of social actors networks was done with the *igraph*, *sna* and *stats* (R-studio). Synergistic and antagonistic governance mechanisms were characterized, and an actor-mechanism interaction matrix was constructed to show the relationship between the type of actor and its governance strategies. There is no clear correspondence between the type of actor and their respective perceived levels of power-affection and interest-dependency of natural capital. The structure of the network perceived changed after the participatory modeling. Different types of actors implement different governance mechanisms, which may depend on their positioning in the network. Social capital and power are associated with synergistic and antagonistic mechanisms, respectively.

Keywords: *Social capital, vulnerability, socio-ecological, ecosystem services.*

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INNOVATIVE MODES OF GOVERNING FOREST ECOSYSTEM SERVICES

Eeva Primmer*

The traditional ways of governing forests, aiming at sustainable timber-production, minimizing environmental impacts and maximizing co-benefits, are challenged by the dramatically increasing demand for more diverse services provision, including climate regulation, risk management, food and energy production and biodiversity conservation. The knowledge and management systems geared to supporting sustainable use as well as the related rights and responsibilities are being rearranged. Seeking for sustainability transformations, and a secured provision of a broad range of ecosystem services, new calls for innovative governance mechanisms have emerged. A European H2020 call for business and policy innovations for sustainable supply of forest ecosystem services is an example.

The identification of new governance modes and their societal embedding must necessarily rest on an understanding the existing mechanisms, and their broader institutional framework, including the constellations of public and private actors contributing to the innovation processes. This paper will summarize the governance mechanisms in place for forest ecosystem service provision in Europe, and introduce a novel institutional mapping designed to support the identification, prototyping and upscaling of forest ecosystem service governance innovations. The emergence of new markets and business opportunities reliant on a broad range of ecosystem services is demonstrated with an empirical analysis of European and exemplary national forest, biodiversity and bioeconomy policies in case study areas.

The analysis unravels the ways in which the innovative governance modes are tackled by actors operating in and around the forest sector, and how these actors' rights and responsibilities become rearranged. The assumption is that new actor constellations and networking activities will benefit from innovation friendly environments, spurring novel policy and business approaches to provide and bundle ecosystem services and benefits in novel ways.

Keywords: *Ecosystem services, governance, institutions, innovation.*

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ROLE OF ECOLOGY MANAGEMENT AND ECO-FRIENDLY TECHNOLOGIES FOR FOREST LIVING COMMUNITY'S LIVELIHOODS: W.R.T. NON-WOOD FOREST PRODUCTS – ANDHRA PRADESH

Teki Surayya*

This study evaluated role of eco-friendly technologies (EFTs) and microfinance to enhance forest living communities' livelihoods. Use of EFTs like stitching machine, compressor, strainer etc., to Non-Wood Forest Products (NWFPs) value additions enhancing people livelihoods by 200% to 300%. Forest living communities adopt unsustainable harvesting methods due to lack of access to EFT. Sustainable harvesting techniques like use of plucking pole reduced forest harming by 40% - 50%. Microfinance accessibility through self-help groups is essential for adoption of EFTs at community.

Methodology: The study was conducted in three forest divisions of Andhra Pradesh. Three villages, in each forest division were selected on direction sampling technique base. Identified the main actors primarily engaged in harvesting NWFPs, explored the scope of EFT adoption with micro-financial assistance. Means of alternative income generation activities; NWFPs value addition with EFTs and poultry farming, piggeries, bee keeping, dairy farming, handicrafts, leave plate making, sericulture, horticulture etc. augmented. Embodies primary and secondary data, primary data gleaned through, a schedule canvassed to randomly selected 180 sample, PRA, discussion with respondents done. Secondary data on NTFP harvesting, consumption, policy documents etc. were collected from the forest department.

Keywords: *NWFPs, Ecology Eco-friendly technologies, Value additions, Communities.*

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Role of external actors on forest institutions: a multidisciplinary approach

Chairs: Maria J. Santos and Clare Barnes

ROLE OF ACTORS IN BUILDING LOCAL CAPACITY TO ACHIEVE FOREST MANAGEMENT AND CONSERVATION

Maria J. Santos*, Ivan Vera Concha and Clare Barnes

Conservation success is dependent on inclusion of multiple actors in the management process. In community forest management (CFM), it is expected that that communities themselves will effectively overcome management dilemmas to maintain and prevent the collapse of their common resources. In many instances of CFM, external actors act as boundaries institutions or capacity building institutions intervening to initiate or further develop the community level action deemed necessary for the sustainable management of community common resources. Different types of actors, however, might result in different outcomes and have varied effects on natural resources. Here we examine two contrasting cases of the presence of external actors in India and in Colombia to assess how do external actors affect the livelihoods capitals of the local communities, with particular focus on the natural capital. We find that in the case of India, the presence of one NGO and one government institution maintains or enhances many of the livelihood capitals, with the exception of natural capital. On the contrary, in the case of paramilitary armed groups in Colombia most livelihood capitals are reduced, and natural capital improved when the armed conflict was permanent. These two cases illustrate how interventions to build local capacity to implement conservation decisions may produce counter-intuitive outcomes, and that we need to better understand different external actor settings to fully assess the success of such interventions.

Keywords: *Interventions, governance, actors, forests.*

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THE WORLD BANK AND FOREST POLICY REFORMS IN SOUTHERN LATIN AMERICA

Sarah Lilian Burns*, Julian Mijailoff and Lukas Giessen

International organizations and their bureaucracies are considered key actors, directing patterns of global change. Among these organizations the World Bank is considered as perhaps the most influential actor bringing about certain types of changes in developing countries. In order to operate, the World Bank uses what is known as blueprints that are then implemented in many different countries with the expectation that they will produce the same results. In dealing with forest policy the World Bank has developed three forest policy initiatives: the 1978 forestry policy, the 1991 and the 2002 forests strategies. With the 2002 forests strategy they promoted private sector investments in forests, new environmental markets and voluntary private sector regulation. In the south of Latin America, the rapid expansion of plantation forests with exotic species observed since the beginning of the 90s was promoted by international actors, like the World Bank, by means of funding and capacity building with the aim of creating a pulp production region in Argentina and Uruguay. While the projects in both countries followed the same blueprint the results observed were very different. Previous research on policy change and bureaucratic reforms focused mainly on domestic factors as explanatory variables. However, international organizations like the World Bank are also important actors leading to domestic policy change. Hence, the aim of this work was to analyze, through process tracing, how the World Bank as an

international organization influenced domestic forest policy change in the south of Latin America and how the interest of domestic actors influences the result of these interventions. Our results focused on two main sources of data: written documents and semi-structured interviews with experts. While the World Bank followed the same blueprint in both countries, our results show that the domestic coalitions and their power determine how effective the World Bank is.

Keywords: *International organizations, forest policy, World Bank, Argentina, Uruguay.*

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PARTICIPATION AND FOREST WATERSHED GOVERNANCE: PERCEPTIONS, REALITIES AND SOLUTIONS

Yemi Adeyeye* and Shannon Hagerman

A central trend in resource governance over the past decade is the increased involvement of non-state actors such as environmental non-governmental organizations. This is also the case in Bolivia, where a number of recent forest management programs seek to involve non-state actors working at multiple scales to enhance forest governance. Yet, questions remain about the nature and extent of participation of different actors in forest decision-making. The Reciprocal Watershed Agreement (RWA), a watershed conservation program in Bolivia, is a program that engages households, water cooperatives, municipal leaders, funding agencies and the state at the various scales at which they operate (e.g. community, municipal, and state). RWA is designed, led and implemented by the NGO Fundación Natura Bolivia (FNB). The objective of the RWA is to develop local institutions to achieve both watershed conservation and livelihood sustenance. Based on 40 in-depth interviews conducted with individuals from the groups indicated above, we examined how different actors view the formulation and implementation of the RWA with respect to the extent and nature of participation in decision-making. Through this analysis, two key themes are identified. Firstly, while the extent and nature of participation in decision-making across different groups varies, with households participating less, all actors seem satisfied with the governance arrangement given an understanding of the importance that FNB interact more with powerful actors such as water cooperatives and municipal leaders. Secondly, high levels of agreement with the objectives of RWA and trust in RWA management agencies underpin the perceived functional governance despite uneven level of participation in decision-making.

Keywords: *Participation, decision-making, non-state actors, institution, governance.*

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COMMUNITY PARTICIPATION IN FOREST CONSERVATION: CASE STUDY OF TWO FRINGE COMMUNITIES IN THE TAIN II FOREST RESERVE, SUNYANI WEST DISTRICT

Nana Yeboaa Opuni-Frimpong* and Peter K. Ania

This study investigated the participation of forest fringe communities in sustainable management of forests reserves in Ghana. Kwatire and Adantia, two fringe communities to Tain II Forest

Reserve in the Sunyani West District of the Brong-Ahafo Region of Ghana were used as case study for this work. The study examined the impact of forest degradation on the livelihood of fringe communities, strategies fringe communities use in conserving the forest, and the level of participation of fringe communities in sustainable forest management programmes. A simple random sampling was used to collect data from a hundred (100) respondents using structured questionnaire in an interview form. The results showed that the Forest Service Division of the district although had a management plan for the forest reserve, action plans outlined in the policies are not carefully followed. Fringe communities were not permitted to collect non-timber forest products so that management plans can have a chance to succeed. The Fringe Communities do not play any significant role in the management of the reserve. There was clear apathy towards the management of the reserve as the communities felt the Forest Services Division was ignoring their knowledge and contributions to the sustainable management of the reserve. Respondents complained of inadequate training opportunities in alternative livelihood sources after been banned from the reserve. The Forest Service Division could liaise with the municipal authority to assist fringe communities in acquiring skills in alternative livelihood sources. Fringe communities should be trained to assist as co-managers of the forest reserve. In addition, regular interactions between Forest Services Division and the communities could reduce unnecessary tension and sabotage and also foster closer collaboration.

Keywords: *Fringe communities, management, forest services.*

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THE IMPORTANCE OF SMALL, BORING THINGS: MICROINSTITUTIONALIZATION AS AN UNDERAPPRECIATED ELEMENT OF ADAPTIVE ENVIRONMENTAL GOVERNANCE

Jesse Abrams*

Scholars of adaptive governance have long argued for the need to transform prevailing institutional arrangements in order to increase opportunities for cross-scale experimentation, learning, and adaptation. However, the hierarchical and centralized systems that characterize many natural resource governance regimes have proven resistant to reform in many cases, and there are relatively few examples of successful transitions to entirely novel polycentric governance regimes. This raises the question of what latitude for adaptive governance exists within the scope of persistent institutional arrangements. Here, I argue that processes of microinstitutionalization, which often result from creative and pragmatic problem-solving via networks, may be important but underappreciated elements of adaptive governance. Indeed, these acts of small-scale institutional tinkering (or bricolage) may, in some cases, accumulate to produce larger patterns of institutional change, either through catalyzing revisions of formal institutions or by constructing parallel informal governance systems in the shadow of formal regimes. I illustrate these possibilities through an examination of microinstitutionalization processes from several North and South American geographies, paying particular attention to the

role of “outside” actors (i.e., those not endowed with formal authority) in conducting institutional bricolage as part of larger networks of action.

Keywords: *Governance, institutional change, networks, bridging organizations.*

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ACTOR NETWORKS AND POWER RELATIONS IN FOREST LANDSCAPE RESTORATION: A COMPARATIVE CASE STUDY OF GISHWATI AND MUKURA LANDSCAPES, RWANDA

Uzamukunda Assumpta*

This study explored the nature of social networks involved in Forest Landscape Restoration (FLR) and relations of different actors in these networks. Many Studies have shown that these networks play a major role in determining whether restoration activities are effective. Two cases of FLR processes in Rwanda have been compared. The two FLR cases were purposely selected in view of their different characteristics. FLR is considered to be successful in Gishwati landscape, whereas the Mukura landscape is still experiencing degradation. These differences are related to different land-use practices and different types of FLR actor networks. The results of this study showed that the differences that exist between Gishwati and Mukura FLR processes depend on the types of actors involved in FLR process, and how these actors interact between themselves and with the communities. An actor network that included all important actors related to the dominant landscape processes, and that was actively involved in FLR on the basis of a specific and well-defined focus on FLR such as reforestation, tree planting and biodiversity conservation, was conducive to effective restoration in the Gishwati landscape. In contrast, an actor network that did not reflect the major actors within the local landscape, resulting in limited connection between the FLR process and mining activities, contributed to limited restoration in the Mukura landscape. The involvement of the communities in both restoration processes is still limited, with decision making about restoration concentrated within government institutions. This study concludes that even if restoration is striving in Gishwati landscape, there is still limited participation of local actors. The FLR networks are often skewed with most actors located at the national level and rather limited connections between national and local subnetworks, and informal or even illegal land-use activities, such as mining activities in Mukura, are disregarded.

Keywords: *Landscape, restoration, actors networks.*

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Multifunctional forest landscapes:
conflicts, tradeoffs and synergies
assessment towards sustainable
forest policy design

Chair: Estela Cristeche and José Gobbi

FOR-POWER: A PAYMENTS FOR ECOSYSTEM SERVICES SCHEME TO PROMOTE FOREST CONSERVATION AND SECURING HYDROPOWER NEEDS OF COMBODIA

Mohit Kaura*

Hydropower relies on protection of watersheds to regulate water and sediment yields. Deforestation accelerates the rate of soil erosion, thereby increasing the amount of river sediments heading to the dam's reservoir, decreasing the longevity of the dam. In Cambodia in particular, recent deforestation rates are among the largest on the planet, and forests are expected to disappear within the lifespan of proposed dams. The cost of protecting and restoring forested watersheds can be considered as an annual investment towards sustainable reservoir management and hydropower generation. A modeling framework is developed to estimate the sediment accumulation in reservoirs from deforestation-driven soil erosion. Associated power generation loss is then calculated, and by relating it to current electricity tariffs, the annualized and present monetary value associated with the benefits of forest conservation to hydropower are estimated. This framework is applied to four large hydropower proposed dams in Cambodia. With an ongoing average deforestation rate of 0.85-1.65% in the past 5 years, reservoir watersheds could lose all forest cover in the coming 40-75 years. This could increase the current sediment yield up by 1.5-1.8 times resulting in acceleration of reservoir filling with sediments, which depending on their size, could lose up to 60-90% of their storage capacity over a period of 100 years. This would incur additional sediment removal costs to the hydropower industry, which could be reduced through investments in forest conservation and restoration, potentially financed via a payments for ecosystem services scheme. The estimated net present values of power loss in Stung Sen, Pursat-I, Battambang-I and Battambang were US \$0, \$1.7, \$1 and \$0.3 million respectively, and could be used as an investment in forest conservation with annual payments made per hectare of the watershed area. The modeling tool is general and transferable to other rivers globally where hydropower development is accelerating.

Keywords: *Payment, ecosystem services, Cambodia, forest conservation, hydropower.*

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BALANCING LIVESTOCK PRODUCTION WITH FOREST CONSERVATION: THE GEF-PSE APPROACH

J. Dante Pueyo*, José A. Gobbi, Adolfo C. Cabral, Víctor Pérez and Franco Del Rosso

To address the loss of native forests occurred in recent decades, a National Forest Conservation Law was approved in Argentina. The Law establishes, among other aspects, compensation for owners who develop sustainable management plans for their native forests that guarantee the provision of ecosystem services from forests to society. Given that the forests in Northern Argentina are under livestock management, any forest management strategy must consider the livestock component in it. In this context, the GEF-PSE Project developed a forest management approach that considers the trade-offs between forest conservation and livestock production. In this sense, it is proposed to intervene up to 20% of the surface of the rural properties to increase livestock production (i.e., introducing improved pastures, water and fences), thus decreasing the livestock pressure on the forest area, and be able to manage forests with an orientation towards

the conservation of biodiversity and the provision of ecosystem services. Operationally, this approach is implemented through the application of a Good Practices Guide and the preparation of appropriate management plans to receive compensation. The Guide was developed following the National Law principles, with multidisciplinary and interinstitutional participation (national and provincial state, universities, producers, etc.). The Guide includes the classification of the forest in three conservation states, according to five indicators, and depending on the state of conservation (favorable, intermediate and unfavorable) are the recommended management practices. The elaboration of the management plans is carried out following the guidelines of the Guide of Good Practices according to the state of conservation of the forest. In the case of the province of Formosa, the approach is tested with 12 producers participating voluntarily in the project. The plans of these 12 producers were presented and are pending their approval to receive funds from the National Law 26331.

Keywords: *Balancing, forest management, conservation, livestock production.*

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CONSERVATION POLICY IN NEW ZEALAND – EFFECTIVENESS IN SUSTAINING FOREST ECOSYSTEMS

Shona Myers*

New Zealand is a global biodiversity hotspot due to its isolation for 80 million years, and the number of endemic threatened flora and fauna species, and unique ecosystems present. Much of the rich threatened lowland forests have been severely depleted and fragmented through intensive agriculture and land use. The majority of lowland biodiversity lies on private land. Conservation relies on management by private landowners, restoration by community groups, and the implementation of resource management legislation and policy. Responsibility for the implementation of policy to protect biodiversity on private land has been devolved to regional and district councils. There are differences in approaches between urban and rural councils, with urban councils having more resources and a higher social responsibility to promote stronger environmental legislation. This paper will discuss the effectiveness of conservation policy approaches by different councils to protect biodiversity. It will also discuss the value of both biodiversity policy and community based approaches to protection, in both rural and urban zones.

Keywords: *Conservation policy private land.*

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LESSONS FROM THE DESIGN AND IMPLEMENTATION OF A PES SCHEME IN NORTHERN ARGENTINA: THE GEF-PSE PROJECT

José Gobbi*, Marcos Atanasio, Carlos Roig and Roberto Gutierrez

To address the loss of native forests occurred in the last decades, a National Law on Forests Conservation was passed in Argentina. The Law establishes, among other aspects, compensation to landowners developing management plans to ensure the provision of forest's ecosystem services to society. In this context, Project GEF-PSE develops a payment scheme for ecosystem services (PES) to promote the implementation of sustainable forestry practices aimed at

improving the conservation status of native forest in Northern Argentina. The approach behind the PES scheme is to compensate landowners according to the conservation status (CS) of their forests, such that a landowner that improves the CS of its forest by implementing sustainable practices will receive a higher payment for ES. The scheme includes four components designed in a concurrent and inter-related manner: i) good practices manual [technical management proposal to improve conservation status], ii) indicators of forest conservation status [monitoring method of the technical proposal], iii) management plans [form of implementation of the technical proposal], and iv) incentives [contracts together with payment amount and conditions]. Twenty-one landowners representing some 40,000 ha are voluntarily participating in the program, are starting to implement their forest management plans, and are receiving payment. Main findings indicate: i) initial investments to adopt forest management plans may represent entry barrier to landowners, ii) PES are marginal to annual cash flows, iii) management plans must be at ranch level to avoid “leakage effect”, iv) a “twenty-eighty intensification-conservation rule” may be relevant to compensate trade-offs, and v) provision of technical assistance becomes relevant to assure forest management success in the long run. A main challenge remains to reconcile farm scale intervention with regional landscape planning to make PES more effective as a tool for forest conservation.

Keywords: *PES, forest, ecosystems services, trade-offs, Chaco, Argentina.*

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THE LOWER DELTA PARANA RIVER INFORMATION SYSTEM. A COLLABORATIVE GIS FOR THE LAND USE PLANNING AND THE DECISION MAKERS

Daniel Somma*, Matías Gaute, Natalia Fracassi,
Javier Alvarez and Roberto Benitez

The design process in the Lower Delta of the Parana River information system was conceived not only from an integration perspective of different sources (also with backing on existing systems) but also, and principally, as a way to involve the stakeholders in the land use planning process of this industrial forest and cattle production region. This stakeholder's involvement configures the backbone of a scientific - technological network. To promote this engagement we consider four pillars of the participatory modelling within the context of policy analysis: ecosystem services conservation planning, negotiation, computer models and stakeholders participation. Particularly, the focus was both compilation of information and implementation of a collaborative GIS approach. This approach is considered as one of the tools to expand and update the knowledge base. The interactions among stakeholders (corporations, foresters, research institutions, government agencies, NGOs, forest organizations) serve as an accelerator to improve the system dynamics in relation with new coverages. Currently, generation of GIS layers became an expensive task if it is carried out by traditional modes. Instead of it, this collaborative GIS, including WebGIS and other technologies (smart phones, social networks) allow the gathering from thematic areas that normally are difficult to collect (eg. biodiversity: presence data of endangered species; hydrological data from islanders). This system approach make also possible to reconstruct land use trajectories and is a crucial support for the land use decision making process. Finally, and specifically for the Forest Core Zone, this collaborative GIS is an information engine for the improvement of logistic and accessibility operations concerning cattle and forest productions, fire prevention and other activities. In addition, it generates relevant inputs to guide landscape connectivity conservation efforts in order to host animals' populations around

the Salicaceae plantations and other areas of the wetlands mosaic in the Lower Delta of the Parana River.

Keywords: *Collaborative GIS, Delta Parana River.*

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FOREST MANAGEMENT AT THE FOREST BASIN LEVEL: A TOOL TO PROMOTE THE SUSTAINABLE DEVELOPMENT OF NATIVE FORESTS FROM A GOVERNMENTAL POINT OF VIEW

Manhattan Ziero*, Sebastián Fermani, Juan Kehler, Alejandro Valerga and Juan Silva

One of the working guidelines of the Forestry Department of the Ministry of Environment and Sustainable Development (MAyDS) of Argentina is to promote Sustainable Forest Management at the Forest Basin Level. Under this approach, one of the criteria to take into account is the social and institutional, which includes the territorial concentration of actors, human resources and institutions linked to the administration and the use of native forests. In this sense, the MAyDS, is working with two forest basins: The Industrial Forest Basin of Monte Quemado in the province of Santiago del Estero and the Forest Supply Basin of Caimancito, in the province of Jujuy. In both parts, inter-institutional spaces were created to debate, suggest and agree on actions aimed at solving the problems identified in the territory. In the Province of Santiago del Estero, the Forest and Fauna Department, belonging to the Ministry of Production, formed by the middle of a provincial law, the Forest Development Commission of Santiago del Estero, made up of several local and national institutions, and its function is to advise the provincial government on the management of the forest basin. In Caimancito, the Forest Bureau of Jujuy was formed, and local actors such as associations, cooperatives and the municipal government was joined. Once the interinstitutional and interjurisdictional working groups have been established, the spatial definition of the boundaries of the basin, the socio-economic characteristic of the basin, the state and potential of the natural resource and the description of the forest production chain are sought. The proposal of a new scale of intervention in the territory and interinstitutionality allows that the actions carried out in the territory have a greater degree of acceptance and participation of society and that the products resulting from these actions are sustained over time.

Keywords: *Monte Quemado, Caimancito, forest basin.*

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ANALYZING LOCAL PARTICIPATION IN NATURAL PROTECTED AREAS THROUGH SOCIAL NETWORK ANALYSIS

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Local participation has been deemed a central factor in the long-term success of natural protected areas (NPAs), particularly amongst indigenous populations with historical relations with these spaces. Participation as an instrument of conservation and management is, in this sense, a popular concept, however a more nuanced definition of the types of participation available to indigenous

communities is a current point of debate. This study analyzes three forms of participation available and practiced by three indigenous Mexican communities where NPAs were either established by the government or created by the communities themselves. Using social network analysis (SNA), the study graphically describes the participation of a large sample of households (150 in total) in the three communities, in the following areas of action: (1) design of NPAs; (2) establishment-related tasks of NPAs; and (3) management of ANPs.

SNA offers the possibility of numerically quantify the degree of involvement of each household in the above forms of participation, assuming that involvement of indigenous communities decreases as it moves from design to daily management activities. In conjunction with qualitative data on the history and politics of NPAs in the communities, a stronger picture of the decision-making processes available or created by indigenous communities emerge. Preliminary results show that in NPAs established by the government, there is a greater involvement of households in management activities and little or no involvement in the planning and design phases. For indigenous established NPAs, a more complex picture emerges. While participation in design and establishment is shared, qualitative research into local power relations is necessary to understand who are the households that participate in these two phases, in comparison to management activities, which under some circumstances are more widespread.

Keywords: *Participation, social network analysis, natural protected areas, Mexico, indigenous communities.*

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ENVISIONING NATIVE FOREST CONSERVATION POLICY: AN INTEGRATED ASSESSMENT USING DISCRETE MULTICRITERIA DECISION ANALYSIS

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The objective of this work is to develop a multi-criteria discrete model to assess and select a conservation policy for the native Caldén forest of the Province of Córdoba in Argentina. The application of the PROMETHEE multi-criteria method integrates a private cost benefit analysis that describes the policy effects on farmers, a contingent valuation study that describes the value of forest ecosystem services assigned by the urban population of that region along with other environmental and social indicators. The decision matrix consists of a long term vision of six policy alternatives evaluated by seven sustainability criteria. The participants of a workshop and key stakeholders reveal their preferences by assigning weight to each criterion. The results show that the most preferred alternatives are extension programs for multiple use of the forest with and without prohibition of deforestation. The PROMETHEE multi-criteria method turned out to be ductile to reflect the interests of the different actors when contrasting results regarding the most desirable policy alternatives. This paper shows the ability of the method to systematize the available information and may help the decision maker to choose the alternative knowing the interest of the social actors. What is more, this type of method offers, from successive approaches, the possibility of reaching agreements among the majorities of the actors involved and accounting

for their multiple interests. It is concluded that multi-criteria methods facilitate the decision making process, assessing policy alternatives by means of a wide range of criteria and by enabling different actors to express their preferences.

Keywords: *Multifunctional forests; Multicriteria Analysis; forest policy.*

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ECONOMIC VALUE OF CARBON SEQUESTRATION IN NATIVE FORESTS OF THE CHACO PROVINCE, ARGENTINA

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Plants and soils can help mitigate increased human-induced atmospheric carbon by absorbing CO₂ from the atmosphere and storing the associated carbon in natural “carbon sinks”. In recent years, there has been a growing interest in estimating the economic value of carbon storage and other ecosystem services. In this paper, the economic value of the ecosystemic service of carbon sequestration provided by the native forests of the province of Chaco, Argentina, is estimated. The replacement cost method is used to estimate the cost of storing one additional ton of carbon in forest biomass. For this, the planting and management costs of a *Prosopis alba* plantation under typical conditions are modeled: medium condition site, with an initial density of 625 plants / ha and a final density of 165 plants / ha at the time of cutting (25 years). Considering a real discount rate of 10%, the cost of storing one ton of carbon is US \$ 19.8 (values April 2015). Taking into account that the Chaco province has some 4.9 million hectares of native forests that capture an estimated of 3.1 million additional tons of carbon per year, the value of the ecosystem service of carbon sequestration provided annually by native forests is approximately US \$ 61.4 million. This amount represented 53% of the value of the province’s production of raw cotton (an emblematic crop in the region) in 2015. This study suggests that the carbon sequestration service and other ecosystem services supported by native forests should be considered when assessing and communicating the returns to society from conserving forests.

Keywords: *Carbon sequestration, economic value, Chaco.*

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TAX AND ACCOUNTABILITY BENEFITS FOR FLR PROJECTS IN ARGENTINA

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Background and objectives: Argentina has some regulations that intend to encourage forest activities through tax and accountability benefits. The aim of this paper is to analyze to which extent those benefits can be beneficial to Forest Landscape Restoration (FLR) projects.

Method: The following aspects of regulations were considered: a) Tax stability for implanted forests, b) Tax stability for non- implanted forests, c) VAT reduction, d) Income tax reduction, e) accelerated depreciation allowance, and f) subsidies for implanted and native forests.

Results and discussion: Some of the Tax and accountability benefits can be beneficial for Forest Land use planning projects. However, some of the current benefits should be adapted for multiple participant's context. Arguably, some adjustment in national legislation can be beneficial to ensure FLR practices.

Keywords: *Argentina- tax accountability benefits.*

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FOREST LAND USE PLANNING REGULATIONS AND FLR IN ARGENTINA

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Background and objectives: Argentina forest law was passed in 2007 and compelled all Provinces to develop and approve forest land use planning in their territories. Since then, almost all the Provinces have approved regulations that classify forest into three categories (red, yellow and green) according to their status for protection. The use of Forest Landscape Restoration (FLR) for degraded forests can encounter some conflicts in yellow and red forest lands. The aim of this paper is to analyze possible interactions between forest land use planning regulations and FLR processes.

Method: Three scenarios were proposed: a) Degraded forest land in red category, b) Degraded forest land in yellow category, and c) Degraded forest land in a mixture of categories. In each of the scenario potential conflicts were analyzed considering regulations, policies and institutions.

Results and discussion: Forest Land use planning regulations in Argentina impose methodological limitations to FLR process. These limitations should be carefully considered when planning for FLR, in order to assure long term successful practices. Arguably, some adjustment in legislation at subnational level can be beneficial to ensure FLR practices.

Keywords: *Argentina FLR land use regulations.*

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TOWARDS PRODUCTIVE LANDSCAPES: TRADE-OFFS IN TREE-COVER AND INCOME ACROSS A MATRIX OF SMALLHOLDER AGRICULTURAL LAND-USE SYSTEMS

Syed Ajijur Rahman*, T. Sunderland J. M. Roshetko and J. R. Healey

One of the main causes of tropical forest loss is conversion to agriculture, which is constantly increasing as a dominant land cover in the tropics. The loss of forests greatly affects biodiversity and ecosystem services. This paper assesses the economic return from increasing tree cover in agricultural landscapes in two tropical locations, West Java, Indonesia and eastern Bangladesh. Agroforestry systems are compared with subsistence seasonal food-crop-based agricultural systems. Data were collected through rapid rural appraisal, field observation, focus groups and semi-structured interviews of farm households. The inclusion of agroforestry tree crops in

seasonal agriculture improved the systems' overall economic performance (net present value), even when it reduced understorey crop production. However, seasonal agriculture has higher income per unit of land area used for crop cultivation compared with the tree establishment and development phase of agroforestry farms. Thus, there is a trade-off between short-term loss of agricultural income and longer-term economic gain from planting trees in farmland. For resource-poor farmers to implement this change, institutional support is needed to improve their knowledge and skills with this unfamiliar form of land management, sufficient capital for the initial investment, and an increase in the security of land tenure.

Keywords: *Deforestation, crop production, tree planting, income, ecosystem services.*

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GOVERNANCE FOR FOREST LANDSCAPE RESTORATION IN ARGENTINA: WHERE DO WE STAND?

María Laura Flores*

Background and objective: Governance is crucial to allow the development of Forest Landscape Restoration (FLR). The increasing bureaucracy and regulatory proliferation in Argentina has created a very complex scenario for the proliferation of FLR. The aim of this paper is to identify advantages and disadvantages of Argentina's legal framework and governance and to propose possible solutions.

Method: We defined forest governance as the rules, practices, policies and institutions that shape how humans interact with forests. We reviewed forest legislation, policies and institutions at a national level. At the subnational level we studied governance at two Provinces (Jujuy and Salta) to analyze interactions and potential conflicts for FLR. When official national data was not available, information was gathered through key informants and interviews.

Results and discussion: Forest governance in Argentina shows clear weaknesses in several areas: interactions between national and subnational institutions, constitutional limitations, bureaucracy, regulatory proliferation and contradictions at different levels, scarcity of the funds made available for the National Fund and difficulties of policy implementation. However, the lack of precision of some of the forest legislation can be considered an opportunity for FLR. Some modest changes in legislation at subnational level are proposed to improve readiness for FLR.

Keywords: *Governance FLR Argentina legal policy.*

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DEFORESTATION, NATIVE FOREST LAW AND PRIVATE CONTROL REINFORCEMENT AT NORTH ARGENTINE DRY CHACO FORESTS

Sofía Marinaro*, Verónica Piriz-Carrillo and Ignacio Gasparri

Subtropical dry forests are among the largest and threatened terrestrial biomes in South America. In Argentina, to mitigate this problem a national "Native Forest Law" was passed in 2007, framing

territorial ordinations of forests. According the category in the ordinations, a forest can be converted, managed but not cleared, or preserved. In the North Argentine Dry Chaco (NADC), one of the most active frontiers for the agricultural advance, a common practice is properties' delimitation. This mechanism consists in fencing and clearing the perimeter, usually previous to forest clearing. In this work we examine how the Native Forest Law modified the dynamic between private control reinforcement and deforestation at the NADC. Specifically, we 1) estimated deforested area at NADC and within-delimited-properties, during 2000-2017; 2) compared percentages of area deforested within-delimited-properties between three periods: before the law was passed (2000-2007), just after the sanction (2007-2011), and since the ordinations until now (2011-2017); and finally, we 3) overlapped area deforested within-delimited-properties, to the classes of the territorial ordination with restriction for clearance; for periods 2007-2011 and 2011-2017. Total deforested area at the NADC reached the 17% of the region at 2017. Total deforested area was 29982 km² during 2000-2017; of which the 24% occurred within-delimited-properties (n=1056). Percentages of area deforested within-delimited-properties were 27%, 44% and 42% at 2000-2007, 2007-2011 and 2011-2017, respectively. A total extent of 2246 km² across the study area was deforested within delimited properties on areas under restriction for deforestation: 1422 km² during 2007-2011, and 823 km² during 2011-2017. Our results showed a no-clear pattern about the destiny of the delimited properties. It could indicate a will of land-cover change, which would translate into the loss of ecosystem services. But it could also represent a mechanism of private control reinforcement, restricting the access of local people, strongly dependent on forest resources.

Keywords: *Dry forests, forest resources, local people, territorial ordination.*

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PLAYING THE GAME: DEFINING INDICATORS FOR INTACT FOREST LANDSCAPES MANAGEMENT IN THE CONGO BASIN

Claude Garcia*

In 2014, the General Assembly of the Forest Stewardship Council adopted Motion 65 that called for the protection of the vast majority of Intact Forest Landscapes (IFL) in FSC certified concessions. To comply with Motion 65, a Regional Working Group for the Congo Basin on High Conservation Values (HCV-RWG) was established in 2016. To support its decision-making process, FSC invited a team of researchers as facilitators. The facilitation team associated Companion Modelling and MineSet. Companion Modelling is a participatory approach based on the development and use of role-playing games to support decision-making. MineSet, is a model of regional landscape change developed to explore the future of tropical forest landscapes in Central Africa over the next decades. MineSet places players in the roles of CEOs of logging and mining companies, interacting with markets, the government and NGOs, planning their activities and developing strategies to cope with the environmental, economic and social impacts of their decisions. It features all the major drivers of land use change in Central Africa: demographics, economic and finance signals, governance and transparency, technological changes, and cultural differences. As the game unfolds, players discover the complexity of the system, and devise new rules and strategies to balance development and conservation. The game and the discussion that follows enables stakeholders to share and confront their perceptions of the system, better grasp

its complexities, explore alternative futures in a low-risk environment, and negotiate new forms of collective action. Thanks to this combination, the RWG could unlock stalled negotiations, level the playing field between participants and move toward achieving consensus in April 2018. This example serves as proof of concept of the use of facilitation and games to address complex negotiations for forest management under conditions of high uncertainty and divergent interests.

Keywords: *Intact Forest Landscapes, FSC, games, commod, companion modelling.*

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MODELING ECOSYSTEM SERVICES IN A FORESTED LANDSCAPE NI RUBBER DOMINANT SOUTH-WESTERN CHINA: CONSIDERING THE RELATIVE ROLES OF LAND SHARING AND SPARING FOR BIODIVERSITY CONSERVATION

Chaya Sarathchandra*

In China rubber is an economically important plant, and has expanded rapidly to occupy considerable land area, including highly diverse rainforests in Xishuangbanna. It provides considerable income to villagers, who have few alternative income sources. Conversion of traditional land management systems to rubber, which supports very low levels of forest-dependent biodiversity, means the loss of ecosystem services, availability and diversity of local food sources, and changes the traditional food consumption patterns.

Identifying strategies for enhancing rubber production is crucial for uplifting local livelihoods and contributing to the nation's development, however, this need to be balanced by strategies that preserve ecosystem services and maintain sustainability. The objectives of this study were to modeling ecosystem functions and services focusing on water, greenhouse gases, soil fertility, and biodiversity conservation, and to explore the impact of different future scenarios on ecosystem functions and services with particular attention to landscape configuration. This research should enable us to suggest policy interventions aimed at optimizing ecosystem services and rubber income, and to develop methods for measuring the impacts of interventions on both biodiversity and rubber income.

We present a novel modelling approach to characterize land use and agricultural decisions, and capture the effects on these decisions on institutional influences such as environmental, zoning, transportation, and agricultural policies. It may be developed to discuss how human activity and its impact on the ecosystem differs under different regulatory regimes.

Keywords: *Rainforest, biodiversity, protected areas, rubber, land use changes.*

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PRIVATE FORESTS FOR PUBLIC GOODS: THE FAMILY FORESTRY IN THE UNITED STATES

Yaoqi Zhang*

Family owned forests have significant impacts on timber supply, rural socio-economic development, and ecosystems in the rural areas. Forests provide multifunction of the ecosystem services, which are often public goods, like carbon sequestration, and semi-public goods like aesthetic landscapes, water conservation and wildlife habitats. Some of those functions are in conflict and some are not. While family-owned forests have been managed for private benefits, they generate substantial public goods for the society when the owners benefit from the public goods provided. Traditionally, we are used to believing that the objectives of private ownership are not consistent with the interests of the general public. But in this study, it is hypothesized that private owners have a lot of common interests with the public. The public benefits tremendously from goods provided by private lands while their owners pursue their own interests. The proposed project will explore what public goods are generated, and understand why and how family forests provide public goods using the case of family-owned forests. The number of family forest owners in the contiguous United States increased from 9.3 million in 1993 to 10.3 million in 2003, and these owners now control 42% of the nation's forestland. The results will be useful in developing policies that can promote private forest management and integration with changing society.

Keywords: *Ecosystem services, multifunctional forestry, externalities, free riders, public goods.*

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IMPLEMENTATION OF PUBLIC POLICIES FOCUSED ON SUSTAINABLE DEVELOPMENT OF THE NATIVE FOREST – FORESTRY MANAGEMENT IN THE YABOTÍ BIOSPHERE RESERVE

José Eduardo Gonzalez and Mariano J. Marczewski*

About a hundred years ago, Michel Laharrague acquired a land area in Misiones, Argentina; not only with commercial objectives, but also thinking about a future for the region. Today, Puerto Laharrague S.A. is a family business located in the city of Montecarlo, province of Misiones. Currently it is oriented to the production of forest raw material, through the implantation of exotic species, and the management of the native forest; being a company with solid roots and innovative fruits. The management of natural resources is carried out within a provincial and national legal framework, broad in forestry and environmental matters; and it is in this scenario where the efforts of forest-industrial management point to the long-awaited balance of economic, social and environmental sustainability. Our general management objectives aim to: (1) use forest products from native forests without deteriorating their recovery capacity and to obtain profitability from forests that is in balance with the environmental and social objectives of forestry, (2) carry out forest operations in order to minimize the associated environmental impacts (3) ensure the safety and occupational health of workers, both their own and outsourced, who perform their tasks in the company and (4) conduct research and develop methodologies that allow managing resources, pointing to their perpetuity over time.

Key words: *Native forest, sustainable development, Misiones.*

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TEN YEARS OF THE NATIONAL LAW 26.331 ON NATIVE FORESTS LESSONS LEARNT AND MAIN CHALLENGES

Juan Pedro Cano*

In 10 years of implementation, the National Law 26.331 had many positive impacts on the native forests of Argentina but still there are big challenges ahead in order to make this law a strong enforcement tool to promote not only the conservation of the forests but also its sustainable use. Argentina has an important diversity of forest regions as well as a wide diversity of actors linked to conservation and industrial development in the forestry sector. One of the biggest challenges is to develop a national forestry policy that can approach the view and needs of the native forests as well as those of the commercial forest plantations from the point of view of the public sector (national, provincial and municipal) and the private sector (industry, academia, innovation and technology, civil society, communities and native people, among others). In this diverse framework the National Secretariat of Environment and Sustainable Development is implementing concrete actions towards a national forestry policy.

Key words: *Argentina, national forestry policy, lessons and challenges.*

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