

SER



2017
Iguassu **Brazil**

Linking Science and
Practice for a Better World

VII World Conference on
Ecological Restoration

V Congreso Iberoamericano y del
Caribe de Restauración Ecológica

I Conferência Brasileira de
Restauração Ecológica

August 27 to
September 1, 2017
Recanto Cataratas
Thermas Resort &
Convention
Foz do Iguassu
Brazil

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for a Better World

BOOK OF ABSTRACTS



Agência Brasileira do ISBN

ISBN 978-85-94244-01-7



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Organizer:

Giselda Durigan

SER / SOBRE / SIACRE

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FICHA CATALOGRÁFICA ELABORADA PELA SEÇÃO TÉCNICA DE AQUISIÇÃO E TRATAMENTO DA INFORMAÇÃO – SERVIÇO TÉCNICO DE BIBLIOTECA E DOCUMENTAÇÃO – UNESP – FCA – LAGEADO – BOTUCATU (SP)

World Conference on Ecological Restoration (7.: 2017 : Foz do Iguassu, PR)
 W927b Book of Abstracts [of the] VII World Conference on Ecological Restoration ; V Congreso Ibero-Americano y del Caribe de Restauración Ecológica ; I Conferência Brasileira de Restauração Ecológica: SER 2017 Linking Science and Practice for a Better World : Foz do Iguassu, August 27 to September 1, 2017, [organizer] Giselda Durigan, José Marcelo Toreza...[et al.]. - Londrina : Sociedade Brasileira de Restauração Ecológica; Society for Ecological Restoration; Sociedad Ibero Americana y del Caribe de Restauración Ecológica, 2017
 450 p.: il.

Available in: URL:<http://www.sobrerestauracao.org>

ISBN electronic version: 978-85-94244-01-7
 ISBN printed version: 978-85-94244-00-0

1. Restoration ecology – Conferences (Meetings). 2. Environmental Restoration – Conferences (Meetings). I. Durigan, Giselda. II. V Congreso Ibero-Americano y del Caribe de Restauración Ecológica. III. I Conferência Brasileira de Restauração Ecológica. IV. SER 2017 Linking Science and Practice for a Better World.

CDD 634.956

THE VII WORLD CONFERENCE ON ECOLOGICAL RESTORATION – SER2017: LINKING SCIENCE AND PRACTICE FOR A BETTER WORLD

This document presents the abstracts of all presentations that built the VII World Conference on Ecological Restoration, which is also the V Congreso Iberoamericano y del Caribe de Restauración Ecológica and the I Conferência Brasileira de Restauração Ecológica. With ten plenary talks, one plenary panel, 60 symposia, 18 workshops and 42 oral sessions, comprising more than 600 oral presentations, and two poster sessions with close to 300 presentations, the abstracts presented here are a synthesis of the knowledge, the ongoing debates, the philosophical reflections and the practice of ecological restoration in the real world. Presentations during SER2017 show a balance in the proportion of scientific and practical approaches, followed by policy making, governance, planning, human engagement, social, philosophical and economic issues.

With 12 concurrent sessions every day, however, each attendee can fully enjoy less than 9% of the entire program, and even with two poster sessions, reading and discussing all posters on display is simply not possible. This book of abstracts provides, at least, a synthesis of each presentation and authors' contacts, so that those reading can search for more information about presentations they did not have a chance to see.

All continents and biomes were represented in the abstracts submitted (Figure 1), with a strong bias towards tropical forests, likely because the science and practice of tropical forest restoration are both quite strong in Brazil, the host country, with about half the attendees of SER2017. It must be highlighted, however, the increasing proportion of studies related to water issues (wetlands, marine ecosystems, water-related ecosystem services, etc.), compared to previous SER conferences, a tendency to be celebrated. This proportion is higher than the proportion of the Earth surface occupied by wetlands and coastal ecosystems, but is certainly below the relative importance of water resources for biodiversity and human well-being, which requires attention and priority in ecological restoration.

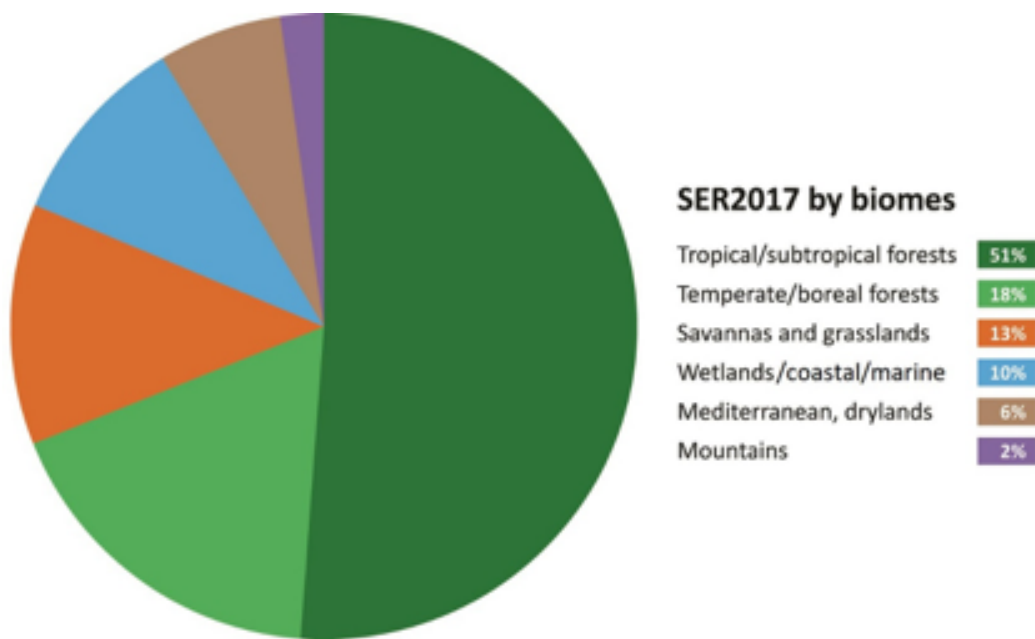


Figure 1. Representativeness of different biomes among abstracts accepted for SER2017 (presentations invited for symposia, contributed oral presentations and posters). Only abstracts providing information about specific ecoregions were considered (n=627).

Each abstract submitted was analysed by two reviewers; some were rejected and many were revised according to suggestions from the reviewers. But most were high-quality abstracts based upon high-level studies or brilliant position pieces. We thank all of the reviewers who kindly devoted part of their time to this job, ensuring the quality of the presentations. We thank the keynote speakers, who accepted our invitation and generously shared their vast knowledge and expertise, with brilliant and stimulating talks summarized here. We thank, particularly, the organizers of symposia and workshops who formed the cornerstones of the conference, and all authors, whose contributions are like the bricks in a building.

Our hope is that the more than a thousand scientists, decision makers, entrepreneurs, students, practitioners and other professionals from 61 countries enjoy the conference, learn from others' experience, which is summarized in this book of abstracts, and make the link between science and practice in their work and daily life, becoming multipliers of the messages from SER2017.

Giselda Durigan

on behalf of the Program Committee – SER2017

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ABSTRACTS / PLENARY SESSION

“A socioecological perspective for multiple scales restoration”

BRIGITTE BAPTISTE

Instituto Humboldt, Colombia

A complete approach to ecological restoration requires a landscape perspective. Functional ecosystems, able to contribute with social wellbeing are a construction that needs to be based both on biological and economic facts, and translated into policy. Frequently, scientific knowledge is not enough to gain legitimacy to develop changes in land use, because decision makers are not convinced nor decided on which path to take, especially if there are complex trade offs to make. However, restoration can be based on a wider perspective of biodiversity management at different scales and with different knowledge systems and linked values, such as IPBES recommends. Examples of the applied framework of the platform and the assessment of land degradation it is carrying, as well as from the Colombian experience of Instituto Humboldt will be presented to promote the discussion of a socioecological perspective for restoration.

An unique opportunity to implement restoration at large scale and address global, national, and local challenges”

MIGUEL CALMON

WRI Brazil

During the last 5 years several national, regional, and global commitments were made towards large-scale forest landscape restoration. In 2011 during a ministerial roundtable in Bonn, Germany, a group of world leaders launched the Bonn Challenge to bring 150 million hectares of the deforested and degraded lands into restoration by 2020. In 2014 at the Climate Summit the New York Declaration on Forests added 200 million hectares by 2030 to the existing Bonn Challenge commitment. By the end of 2016 a total of 39 commitments have been made by countries, sub-national jurisdictions, companies, and regional restoration initiatives, totaling 136 million hectares towards the 350 million hectares by 2030 target. In terms of regional commitments, two major initiatives were launched in Latin America and Africa. The Initiative 20 x 20 is a country-led effort to bring 20 million hectares of land in Latin America and the Caribbean into restoration by 2020. The AFR100 Initiative is also a country-led effort to bring 100 million hectares of deforested and degraded landscapes across Africa into restoration by 2030. Both initiatives contribute to the Bonn Challenge. More recently over 100 UNFCCC Parties have included land sector targets in their NDCs, and those with restoration/reforestation/afforestation related targets surpass 150 million hectares. There is no question that we have the greatest opportunity to demonstrate how those national and international commitments can help address global, national, and local challenges, and at the same time generate the expected benefits. Several examples will be presented to show some progress towards the implementation of those commitments and the benefits being generated, but we still have some challenges to overcome in order to make those inspirational targets an asset to the society that depend on the goods and services generated through forest landscape restoration.

Can we manage for resilience? Making decisions about where and how to restore in a changing world

KATHARINE SUDING

University of Colorado

In a world experiencing rapid changes in climate, disturbance regimes, and land use, managing for resilience to future threats has become an essential goal in the science and practice of restoration. However, in many settings, it remains unclear how to actually incorporate resilience into restoration frameworks. We face a series of challenges: how to assess resilience across complex landscapes, how to identify the components that impart resilience, and how to develop ways to incorporate this understanding into management decision making. Over the last decade, our work aimed at linking restoration and environmental change emphasize that resilience can be both desirable and undesirable: it can allow conserved landscapes to better withstand future threats and can assist recovery of degraded lands, or it can stymie change and require management intervention to spur

recovery. In addition, it points to the great potential of understanding feedbacks that underlie resilience, utilizing them to enhance or break resilience cycles, or in severe cases, to modify management goals.

Innovation in Restoration: Barriers and Opportunities

JAKKI MOHR

University of Montana

Successful planning and implementation of restoration projects, whether large or small, is fraught with difficulties. Whether it is managing stakeholder relationships, navigating tensions in goals and objectives among various stakeholders, or identifying the best protocols to follow to restore a degraded ecosystem, conflicts and tensions abound. Entrenched practices and relationships can make it difficult to identify new ways to address such conflicts and tensions. Using the lens of innovation, Professor Mohr will address opportunities in restoration practice, as well as barriers to innovative thinking and ways to overcome those barriers.

Linking science and practice to safeguard coral reefs in the Anthropocene

TERRY P. HUGHES

Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University

Coral reefs support immense biodiversity and provide key ecosystem services to many millions of people. A defining feature of the emerging Anthropocene Era is the escalation of multiple pressures, such as rapid climate change, globalization and migration, and their effects on society and the world's ecosystems. Already, many coastal coral reefs have been degraded by centuries of overfishing and pollution, and anthropogenic climate change is adding further stress, even on more remote reefs where local pressures are small or absent. Over the coming centuries reefs will run the gauntlet of climate change, when rising temperatures will transform them into new configurations unlike anything previously experienced by humankind. Returning coral reefs to past configurations is no longer an option. Instead, the global challenge is to steer reefs through the Anthropocene in a way that maintains biological functions. Navigating this transition successfully will require radical changes in coral reef science, management, and governance. Restoration projects to date have typically focused on restoring populations of depleted species, such as turtles or targeted corals, often without adequately addressing the drivers that caused their decline in the first place. A broader approach, that seeks to reduce multiple pressures and repair key processes, such as herbivory and recruitment, remains largely unexplored. Focusing on processes, ecological functions, ecosystem services and human drivers opens many possibilities for more active management interventions.

Restoring forest biomes: advances and challenges

ROBIN L. CHAZDON

Department of University of Connecticut, Storrs, CT

Research and practice of forest restoration have grown dramatically over the past 10 years, motivated by the urgent and growing need for solutions to reverse effects of deforestation and degradation at multiple scales. I provide an overview of the advances and challenges related to the science, governance, costs, and benefits of restoring forests in tropical, temperate, and boreal biomes. Climate change imposes additional challenges for the science and practice of forest restoration in response to growing local and global needs for ecosystem goods and services. Scaling up forest restoration to reach the large scales needed remains a major challenge and will require an increasing emphasis on spontaneous and assisted natural regeneration as well as new conceptual approaches and policy frameworks to support landscape-scale restoration initiatives.

“The world's water systems: a gram of prevention, worth a kilogram of cure”

CHARLES J. VÖRÖSMARTY

City University of New York

Fresh water is widely regarded as a fundamental, if not the most critical, natural resource upon which the future of humankind will depend. It underpins countless benefits to society and is pivotal to the success of the food and energy sectors, industry and commerce, and an expanding urban domain. It also provides essential cultural, recreational, and aesthetic values. Water is unsubstitutable in the context of maintaining aquatic habitat and biodiversity and the so-called ecosystem services that nature provides. A recent and growing body of evidence on water systems across the planet points to a pandemic array of threats through which much of the fresh water resource base that sustains society has been placed in jeopardy. Today we see a globally significant approach to water management, through which impairment accumulates with increasing wealth but is then remedied by costly, after-the-fact technological investment. This strategy of treating symptoms rather than underlying causes is practiced widely across rich countries, but it leaves poor nations and much of the world's aquatic life forms under high risk. The seeds of this modern impair-then-repair mentality to water management were planted deeply within human history when limits were barely perceived or in fact were hardly the reality. Yet, the wisdom of our "water traditions" may be ill-suited to an increasingly crowded world with aspirations for continued economic development, growing natural resource constraints, and the inevitable impacts of climate change. Exploring the nature of human-water interactions today, how we got here, and where we are going is the subject of this talk. The focus is on rivers, which collectively provide the bulk of society's water needs. I will focus on the evolution of human-water systems using a long-term historical perspective, which I see as essential to understanding the full dimension of the contemporary and future global water crisis. For water, the situation in 2017 did not materialize spontaneously and is but one point in an historical continuum of change. The implications for the sustainable development agenda, while obvious, will also be discussed.

Turning good intentions into good outcomes: links and mismatches between theory and practice in restoration

RICHARD HOBBS

University of Western Australia

Considerable advances have been made in both the science and practice of restoration over the past 2-3 decades, and there are many examples of successful restoration projects around the world. At the same time, however, our understanding of how ecosystems work has developed rapidly, leading to a need to rethink some of the basic tenets of restoration ecology. Ongoing human alteration of the basic biophysical settings of our planet (including climate and species distributions and abundances) has also led to vigorous debate regarding what appropriate goals and approaches might be into the future. The science and practice around these questions is still evolving, as is the appreciation of the ethical and value-based issues involved. Most people involved in restoration have good intentions – the task for the future is to ensure that the science and practice result in good outcomes too.

What do we know about tropical grassland resilience and restoration?

ELISE BUISSON¹; SOIZIG LE STRADIC^{2,3}; FERNANDO A. O. SILVEIRA⁴; ALESSANDRA FIDELIS³; GERHARD E. OVERBECK⁵; GISELDA DURIGAN⁶; G. WILSON FERNANDES⁷; JULIA-MARIA HERMANN⁸; WILLIAM J. BOND⁹; GREGORY MAHY²; NICHOLAS P. ZALOUMIS¹⁰; JOSEPH W. VELDMAN¹¹

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Despite growing recognition of the conservation values of old-growth grasslands, our understanding of how to maintain and restore biodiverse tropical grasslands (including savannas and open-canopy woodlands) remains limited. Toward better incorporation in conservation efforts, a review of the current state of knowledge on tropical grassland resilience and restoration will be presented. Tropical grassland plant communities are resilient to – and often dependent on – the endogenous disturbances with which they evolved, such as frequent fires and native megafaunal herbivory. In contrast, tropical grasslands are extremely vulnerable to human-caused exogenous disturbances, particularly those that alter soils and destroy belowground biomass (e.g. tillage agriculture, surface mining). Grassland restoration after severe soil disturbances is expensive and rarely achieves management targets. In grasslands degraded by altered disturbance regimes (e.g., fire exclusion), exotic plant invasions, and/or afforestation, restoration can recreate historical vegetation structure (e.g., tree density and herbaceous cover), but species-diverse herbaceous plant communities are typically slow to recover. Complicating plant community restoration efforts, many grassland species are difficult to propagate; reestablishment of long-lived species that invest in underground storage organs is a particular challenge.

ABSTRACTS / ORAL PRESENTATION**S01** Landscape restoration: reducing the gaps between theory and practice**Organizer: Cristian Echeverria****S01.01 - What is landscape restoration? Definition, implications and practical challenges**

CRISTIAN ECHEVERRIA

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Diverse global and national initiatives and agreements seek to promote ecological restoration at large scale. For instance, the Global Partnership on Forest and Landscape Restoration is a network based on a landscape approach and responds to the Bonn Challenge to restore 150 million hectares. However, we believe that little consensus exists on the definition and methodological approaches needed to conduct landscape restoration (LR). The objective of this work is to present a definition of LR from landscape ecology perspective and discuss some implications and practical challenges.

Landscape ecology perspective and, in particular, landscape sustainability science (LSS), can make a profound contribution to a better understanding of this concept. Thus, LR can be defined as the planned process of recovering the capacity of a landscape to consistently provide long-term, ecosystem services essential for improving human well-being. In other words, LR seeks to improve key attributes of a landscape including composition, configuration and dynamics that are spatially interacting with ecosystem processes, biodiversity (at different levels of organization) and ecosystem services. I present a case study to discuss implications of this definition and exemplify practical challenges of how dealing with LR by integrating these key attributes. The study landscape is located in the core of a biodiversity hotspot, with a substantial loss of natural ecosystems, a landscape profoundly transformed by economical drivers, and an explicit need from local community and relevant stakeholders to recover essential ecosystem services in order to improve their well-being.

S01.02 - Scaling up ecological restoration to the landscape scale: added value of the restoring natural capital concept

JAMES ARONSON

CCSD, Missouri Botanical Garden, 4333 Laclede Ave, Unit E, 63108, St Louis, Missouri, United States. ja42014@gmail.com

At the landscape scale, and indeed at larger spatial scales, it is essential to consider both ecological restoration as just one component in a 'family' of restorative activities that must be deployed to make ongoing human activities and land water and other resource uses more ecologically, economically, socially, and ethically sound and sustainable. A valuable concept here not to be overlooked is that of restoring natural capital, which is the product of 15 years of inter-disciplinary discourse between ecologists and economists focusing on the benefits and costs of restoration.

Based on studies and observations in both tropical and extra-tropical restoration projects and programs, we present a new model that could help orient monitoring and evaluation, scaling-up, and application of a family of restorative activities in new areas. We compare its underpinnings and merits with conceptual frameworks embedded in the SER International Standards document and in the Global Partnership for Forest Landscape Restoration's programmatic work. We consider restoration on both public and private lands, and our main audience is government and private sector investment policy-makers looking for long-term gains in terms of benefit cost ratios.

S01.03 - What is a landscape ecology perspective and why it is important for restoration?

JEAN PAUL METZGER; PEDRO BRANCALION

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Face to the large demands of restoration worldwide, there is a growing interest in understanding how landscape factors act on restoration processes. However, with the increasing spatial scale of restoration programs, semantic confusion abounds, and terms like “landscape restoration”, “large-scale restoration”, “landscape-scale restoration” and “restoration with a landscape perspective” have been used as equivalent, although they are not. Our objectives here are to present the “landscape ecology perspective in restoration” and to show how this perspective can optimize restoration actions and enhance its effectiveness in transforming landscapes. A landscape perspective considers the influence of the landscape structure on the restoration potential, as well as the impact restoration may, in turn, have on the landscape. This perspective goes beyond restoring pieces of the land or even restoring large areas, while ignoring the influence of the landscape structure. By explicitly considering the spatial interrelationships between landscape structure and the ecological processes involved in restoration, this perspective can be used to efficiently scaling-up restoration actions. A landscape perspective can inform prioritization of restoration sites, enhance and speed ecological recovery, and improve restoration cost-effectiveness. This new perspective brings new challenges for the restoration science, which needs to understand better the relationships between the landscape structure and all the processes related to ecological restoration, but also offers new opportunities to make landscape restoration more effective.

S01.04 - Participatory cartography of priority areas for restoration at the regional scale

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The effective integration of ecological restoration (ER) into land use management requires the definition of priority areas and actions. At large spatial scales, priorities are commonly defined by experts in terms of ecological factors, particularly species distribution or a small set of ecosystem services. However, management decisions must deal with different habitats, and respond to society multiple demands and aspirations. New tools for identifying and analyzing priority criteria and determining best management alternatives, integrating ecological and socio-economic assets are needed. We developed a participatory approach to identify priority areas for restoration in a 224,472 ha area in southeast semi-arid Spain. The challenge was to develop a rigorous yet accessible methodology that could be extrapolated to other regions. An 88-stakeholder platform was asked (i) to identify and weight priority criteria for ER, and (ii) identify and weight the main ecosystem services obtained from each landscape unit. We collected mapped information on identified criteria and services, and defined candidate areas for restoration on the basis of the current and potential provision of ecosystem services. We assembled restoration protocols for such areas, and estimated their costs. We then built a map of priority areas for ER, and a map depicting the cost:benefit ratio of ER. Benefits of ER were estimated as the integrated value of the increased provision of services. Finally, we identified high priority areas with lowest cost:benefit ratio. The information collected will be used to discuss best strategies for ER, and engage the private and public sectors in ER initiatives.

S01.05 - Use of geospatial technologies for the definition of high-priority areas of restoration. Importance of the spatial and multicriteria analyses

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The use of geospatial analyses for the design, planning, implementation and monitoring of restoration strategies is a very important tool to prioritize and define areas of restoration. According with the scale, it broadly allows to analyse the needs of restoration in a particular region and to develop strategies to restore natural ecosystems and to contribute to stakeholders to take better decisions. The Humboldt National Biodiversity Institute is trying to develop protocols and tools to better define areas for restoration in the country. Also, we want to contribute to the goal of restoring one million hectares by 2020 and to put restoration as an opportunity for the implementation of the peace agreements with the FARC guerrillas in Colombia. We already prioritized areas at a 100.000 scale including the entire country as a part of the National Map of Restoration for the Environmental Ministry project. At the same scale in other projects, we prioritized areas of wetlands, tropical dry forest, páramos and forest using landscape metrics such as size, shape, core area, land use types, landuse conflicts and drainages. We found that for areas like the ecosystems of Colombia, many variations of social and biological conditions exist. We conclude that the analyses must be fitted to the particular field conditions to better aboard the objectives, design, viability and implementation of restoration strategies.

002 Adaptive management for restoration in forest ecosystems

002.01 - Piloting restoration initiative in subtropical scrub forest of Pakistan- specifying and identifying areas where restoration will need additional interventions

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Pakistan's subtropical scrub forests have diminished by some 70% over the last hundred years, mainly due to indiscriminate exploitation and invasion by exotics species. Lack of initiatives, awareness and research in utilizing the techniques used for accelerating natural forest succession is resulting in further degradation of the remaining forest. To promote natural regeneration with local communities and governmental authorities, a restoration scheme was piloted between 2010 and 2016 to examine population reinforcement effects. Over 4,000 saplings of two woody climax species, *Acacia modesta* and *Olea ferruginea*, raised from seeds of local provenance, were planted in three subjectively selected trial plots representing various stages of degradation, covering a total area of about 5 ha. With an overall 46% seedlings' survival rate, reinforcement plantings accompanied by other conservation measures have also facilitated natural regeneration. However setbacks, resulting from natural as well as human-induced causes were also experienced. The frequency of maintenance operation were adjusted according to the field observation on the growth of the saplings in terms species vulnerability, active and passive restoration and elimination of potential threats at the three sites. Comparative analyses of the trial plots have shown substantial variations which were strongly site specific. This study would provide an opportunity to appreciate the differences across the landscape in terms of restoration interventions that can be used as an effective management tool to upscale restoration across the entire degraded scrub forests of Pakistan.

002.02 - Adaptive management of *Eucalyptus* sp. plantation stands to restore the Brazilian Atlantic Forest

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Aiming at to comply with forest certification principles and criteria and environmental legislation, many eucalyptus forests plantations in Brazil need to be converted back into native forest. In many instances, clearcutting followed by plantation of native tree species seedlings is the preferable choice, due to the lack of natural regeneration. Nevertheless, in plantation stands with a relatively rich understory, other approaches are still to be tested. We designed a complete randomized block experiment with six treatments and four replicates in a third-rotation *Eucalyptus saligna* Smith. to test the native vegetation response to increasing thinning levels. The experimental is located at "Neblinas" Park, Bertioga municipality, São Paulo-BR, within the Atlantic Rainforest domain. The treatments were: T1= control; T2-T5= reduction of respectively 25, 50, 75 and 100% of the eucalyptus trees basal area, through girdling and poisoning and T6= clearcutting, in 20 x 40 m permanent plots. After 12 years, it is possible to notice a positive successional trajectory of the native vegetation on the treated plots, compared to the control. Treated plots had an average increase of as much as 100.16% in basal area; 95.23% in species richness and 59.82% in the absolute density of native tree community (individuals with D.B.H-diameter at breast height equal ≥ 5 cm), in comparison to the untreated plots. T4 (reduction of 75% of stand basal area by girdling) resulted in best development of Atlantic rainforest tree community structure, while having an intermediate management cost.

002.03 - Restoring plant diversity and productivity of Miombo woodland in southern Africa through selective stem thinning in stand development stages

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Most of rural society in Africa depends on resources from seasonal woodlands. Extensive Miombo woodlands in southern Africa provide mainly fuel wood, poles and land for crop cultivation to rural society. People think that these woodlands become degraded and deforested. Recent ecological studies raised the question that maybe we overlook the ecological need for cyclic change to maintain their plant diversity and productivity. This presentation will demonstrate how underground rootstocks of most Miombo tree species and their light requirements need clear-felling of mature stands to enable fast regrowth, and how stand development stages provide for sustained use of poles and fuel wood by rural society, and biodiversity and productivity recovery. Experimental thinning (0-100%) in two blocks each in three stand development stages were implemented in northern Tete Province, Mozambique, during 2014. Recovery from cut stems, and height and diameter growth of remaining stems were recorded. Vegetative regrowth is fast but this rate of regrowth (% of stems and growth in height and diameter) decreased with decreasing thinning percentage. This requires a different approach towards sustainable resource use, i.e. selective thinning and pruning of stems, and eventual clear felling of mature stands to rejuvenate the system. This integrated multiple use approach will maintain the supply in fuel wood and poles, maintain plant diversity, improve condition and productivity of the woodlands, increase carbon stocks and maintain a high rate of carbon sequestration, all benefitting the rural small-scale farmer - in sharp contrast to the moribund old-growth stands in protected areas.

002.04 - Increasing density and richness by cutting trees in the Atlantic Forest restoration

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There is growing recognition that natural regeneration – i.e., spontaneous tree recruitment that occurs without seeding or transplants – is an important forest ecosystem function that can contribute to the restoration of deforested land. This emerging view contrasts with conventional forest restoration efforts that emphasize tree planting, often at high densities. We conducted a tree thinning experiment at a restoration site in the Atlantic Forest of Brazil, planted with 29 native tree species in 1990 at a density of 2,000/ha, where tree basal area (BA), after two decades, exceeded reference ecosystems by 30%. The experiment included three treatments: control (no thinning); light thinning (30% reduction in BA, i.e., equal to reference ecosystems); and heavy thinning (60% reduction in BA, i.e., 30% below reference). One year after thinning, recruitment of native trees (> 0.5 m tall) in the heavily thinned plots was 18 times greater than the unthinned controls; light thinning had no significant effect on natural regeneration. Tree species richness increased in all treatments but was greatest in heavily thinned plots (eight new species, a 22% increase) compared to lightly thinned (5 new species, 15% increase) or control plots (4 new species, 11% increase). Species recruiting are native trees from forest remnants in the neighborhood, mostly animal dispersed, and some are those planted. Because dense restoration plantings can limit natural regeneration, we suggest that heavy thinning, decades after initial reforestation plantings, may be considered as a potential management option to enhance recruitment and increase species diversity of restored Atlantic Forests.

002.05 - Long-term forest regeneration monitoring as a tool for adaptive management in protected areas

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Strict protection reserves must comply with management rules that will only allow intervention in specific cases. It's imperative that any decision to actively promote restoration of a degraded forest inside a protected area is based on evidence, informed by field investigation. We present the main results of a forest regeneration monitoring effort, known as Succession Project, which took place at Salto Morato Reserve, located in Guaraqueçaba, in the Brazilian Atlantic Forest. The goal is to discuss how evidence-based information was strategic for the reserve management, especially for the decision about actively restoring a spe-

cific disturbed area or not. It wasn't clear if the forest resilience in a patch of the reserve had been compromised after decades of small-scale land use (deforestation, agriculture, cattle grazing) before the lands were acquired and the reserve created (1994). Responding to this management demand, 35 permanent plots were set and the forest succession monitored, from 1999 to 2017. After the third year of monitoring, the forest's successional dynamics provided indicators that suggested a non-intervention approach, as the observed resilience was considered sufficient for the natural regeneration to take place. That recommendation was proved to be correct: after sixteen years of regeneration, the sampled area was composed of 88 trees and shrubs species, with a basal area of 20.25 square meters per hectare. Nevertheless, the abundance of some invasive species required longer observation and concern. Therefore, this case study illustrates the importance of expert diagnostic whenever a crucial management intervention is considered, especially in protected areas.

002.06 - Forest restoration after severe degradation by coal mining: Lessons from the first years of monitoring

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We analysed woody plant species regeneration in the first years of restoration in areas severely degraded by coal mining in the South Brazilian Atlantic Rainforest. In the four riparian forests under restoration and in two forests remnants, we collected data of the herbaceous layer (including invasive grasses), abundance and richness of introduced trees and spontaneous woody regeneration, traits woody species, and soil chemistry. We compared characteristics of the woody regeneration with the forests remnants as target communities and evaluated the dynamics of regeneration over three years by principal coordinates analyses (PCoA). The influence of biotic and abiotic variables for woody species regeneration was analysed by partial redundancy analysis (RDAP). We found great variation in relation to community composition and structure between restored sites. Most of this variation was explained by variables related to soil chemistry, introduced trees and cover of exotic grasses. Fertilization of soil, as commonly recommended, seems to increase cover of exotic grasses, which clearly impedes the development of planted trees and woody regeneration. Over time, an increase in woody species establishment could be observed. Although the restoration of abandoned mining areas is a challenge for restoration, our results, despite the short period of observation and high mortality of planted trees, do allow for the conclusion that the restoration of successional trajectories after severe degradation is possible. We highlight the importance to monitor the initial process of restoration and of (re)defining intermediate goals and project targets, following an adaptive management approach and linking science and practice.

S03 Monitoring indicators of restoration in Brazil: How we are doing in practice?

Organizer: Maria Otávia Silva Crepaldi

S03.01 - Collecting indicators in an efficient way

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The main goal of ecological restoration is to enable the natural process of ecological succession towards the non-degraded condition. Monitoring is crucial to evaluate the success of the restoration process, both in relation to the methods used and the ecological trajectory that is being followed. Although being essential, initiatives to perform a periodic monitoring in areas that were restored with native species are still scarce. For monitoring changes in the structure and sustainability of ecosystem restoration, several ecological indicators are analysed. Ecological indicators are divided into composition (existing species and relative abundance), structure (vertical organization of vegetation), pattern (horizontal organization of vegetation) and functioning (performance of the main ecological processes). The ecological indicators most used are: ground cover of native vegetation (%), density of native individuals (individuals/ha), number of species (richness) and canopy cover (%). But depending on the scale, there are other possible indicators, such as litter decomposition or evaluation of the natural vegetation index through remote sensing. An efficient monitoring can consume a lot of resource and technical hours and be more frequent at the beginning of the restoration process. For the forest ecosystems, many specialists and institutions are discussing about monitoring and created some protocols. However, for non-forest ecosystems, the ecological process is different therefore is necessary more development to this approach. The purpose of this presentation is to show several forms of monitoring for the different phytophysiognomies across Brazil and how we are doing in theory and practice.

S03.02 - Restoration monitoring at landscape scale

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In Brazil, there are large areas in different settings and stages of restoration, such as restoration projects for companies, small producers, government, non-governmental institutions, conservation projects and others. The monitoring phase in restoration projects is challenging because it is difficult to collect large-scale data, and from different phytophysiognomies. Therefore, it is important to use a good field protocol such as remote sensing and other technologies to make decisions about the projects. We need more research identifying methods to analyze areas in the process of restoration, which means we need to choose a strong indicator and identify its patterns in monitoring via remote sensing. Currently, we select native species cover as an indicator of restoration quality, mainly in the initial stage of the ecology process, when the structure of native vegetation is available. In a preliminary study in Brazil's Atlantic Forest, The Nature Conservancy and partners obtained high resolution satellite images to analyze via remote sensing the difference between canopy cover, grass cover and arbustive cover. Following such analysis, we compare and identify the patterns in others phytophysiognomies, such as the Caatinga and Cerrado biomes. We believe this would allow us to have broad and high-quality monitoring and restoration in a country as diverse as Brazil.

S03.03 - Monitoring dune restoration in Parque Estadual de Itaúnas, protected area in Espírito Santo - Brazil

SCHIRLEY COSTALONGA

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Environmental monitoring is crucial to evaluate the success of ecological restoration. The monitoring technique chosen should provide reliable results and consider the biodiversity of the monitoring area and impact on local species. A project to restore a dune area which had suffered successive species decline was undertaken in Parque Estadual de Itaúnas, a protected area of Espírito Santo, south-eastern Brazil, in 2010 and 2012. Initial monitoring was carried out between December 2010 and March 2011, using a traditional methodology where native species diversity, height and cover were used as indicators of restoration success. During the second phase in 2012, native and alien species cover and percentage soil cover were recorded by the line intercept method, with the establishment of eight lines with 10 meters, at intervals of 5 meters, for a total of 80 meters of sampling. This was done in the third, eighth, sixteenth and twenty-fourth month after project implementation. When compared with a traditional methodology, where the growth of each individual was evaluated, the line intercept method was more efficient. In addition to easier and faster application, it provided a clearer method to quantify percentage of soil cover by native and alien species.

S03.04 - Restoration monitoring in semi arid ecosystems

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The challenges of restoration of the Caatingas of the São Francisco River aim to understand the phenomena involved in the restoration of seasonally dry environments, whose main limiting factor is water. Thus, CRAD / UNIVASF develops theoretical studies, alternative technologies and practical activities involving planting methodologies and monitoring protocols to evaluate the performance of the restoration. The main issues are related to the role of facilitation in restoration, knowledge on the natural history of native Caatinga species, technology to produce species seedlings and alternative substratum production practices, restoration with water management efficiency, and to test the role of goats and sheep as herbivores and of emas as potential dispersers in the maintenance of the Caatinga biological diversity. The main results reveal the need to safely identify survival rates of predominantly deciduous species and annual species with unusual survival strategies. Thus, the main limitation of monitoring is the minimum time required to obtain responses considering the slow development of Caatinga woody species when compared to mesic ecosystems. Thus, it is necessary to include in the restoration strategies, original solutions based on the natural history of the species and the ecological processes involved, important for the success of the monitoring vegetation. The resilience of the Caatinga in this period of multiannual droughts must also be considered in response to the continuous global temperature increases unprecedented in this biogeographic region of Brazil that limit the efficiency of restoration actions.

S03.05 - Monitoring forest restoration through the use of convergent methodologies in diverse physiognomies

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Considering the legal and administrative perspective, tropical forest restoration initiatives are aimed to compliance environmental legislation and the restoration of ecosystem services. According to the International Society for Ecological Restoration the goal of a restoration project should be recreate a self-sustaining ecosystem, resistant to human disturbance. The aim of this work is to present the experience of development of protocols for monitoring and evaluation of restoration for a subnational environmental agency in Rio de Janeiro State, at Brazilian southeast, using three protocols: Ecological Rapid Assessment (DER), Environmental Rapid Assessment (DAR) and Remote Sensing Assessment (RSA) for support the decision makers on the evaluation of the restoration projects. Each protocol was adjusted accordingly with the type of vegetation, divided as forest, mangrove,

restinga and agroforestry systems (AFS). The number of parameters varies from 9 parameters to evaluate AFS, 7 for forest and resting and 4 to mangrove. The protocols are adopted as a public policy, and set clear rules of environmental licensing and off-setting policies. There was an established reference value to be achieved, which guide the goals of the project and are controllable by the executor enabling corrective actions. The protocols filled the gap tools to support decision making. The methodologies can be applied by technicians of different Levels of experience, and also standardize the evaluation by the environmental body, reducing the subjectivity of the project.

S04 Field-based focal training sites: Examining a unique opportunity to link scientific research and applied experience to develop capacity for ecological restoration

Organizer: Gillian Bloomfield

S04.01 - Exploring the potential of field-based focal training sites to link applied research with capacity building for place-based, experiential learning on restoration

EVA J. GAREN

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Developing the capacity of communities, practitioners, landholders and decision makers to implement an array of strategies to restore tree and forest cover in tropical human dominated landscapes is an essential step in order to meet a range of emerging restoration interests and targets. This process involves linking the people who manage and influence tropical landscapes to scientific data and applied experience on an array of restoration approaches in different contexts. The development of field-based training sites that encompass a history of scientific research on restoration and a network of applied projects and demonstration sites is proving to be a unique and impactful approach to experiential, place-based capacity development. We examine the design and experience of emerging field-based training sites focused on ecological and forest restoration in the tropics in the Neotropics – Panama, Colombia and Brazil – and in S.E. Asia – the Philippines and Indonesia. We look specifically at: (1) the context of social and ecological research and applied experience that each site includes; (2) how the sites incorporate both research and applied experience into teaching curricula and demonstration sites and activities; (3) why this model of experiential learning is emerging as a promising approach to capacity development for restoration; and (4) how these field-based experiences can be incorporated into an online training platform. Additionally, we will discuss the vast opportunities that the field-based training sites offer for researchers, practitioners, landholders and policymakers who wish to be involved with capacity development and restoration throughout the tropics.

S04.02 - El Hatico training site in Valle del Cauca, Colombia: Land rehabilitation integrated to sustainable livestock production and organic agriculture

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Cattle-dominated landscapes offer the largest opportunity for ecological restoration in Latin America with 660 million hectares of pasturelands in the region and 35 million hectares in Colombia. For the majority of cattle ranching lands, rehabilitation with sustainable silvopastoral systems that enhance productivity while recovering environmental goods and services is more feasible in social and economic terms than restoring ecosystems to a historic or pre-existing condition. However, most farmers, professionals and extension workers are unfamiliar with the scientific principles and management protocols of silvopastoral systems. This talk highlights the experience and potential for field-based training sites to meet the growing need for capacity building on silvopastoral and other sustainable agriculture and restoration practices. We provide the example of the El Hatico Reserve in Valle del Cauca, Colombia, which is a 240-hectare farm managed continuously by nine generations of a single family. El Hatico is widely known as a pioneer farm in the adoption of silvopastoral systems and organic sugar cane, both of which apply the principles of agroecology, yet are considerably more productive and profitable than their conventional counterparts. This Reserve's long history of scientific research and applied experience serves as a basis for capacity building on ecological restoration integrated with sustainable agriculture and cattle ranching. By demonstrating that a biodiversity frie

S04.03 - Influencing landscape restoration through science-based capacity building in the Dry Tropical Forest of Panama

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Despite the historical loss of tropical forests throughout Latin America, in recent years there has been further understanding of the value of forests and consequently increased forest restoration initiatives. In order for decision-makers to adequately utilize applied ecological science to implement landscape restoration initiatives, this information must be disseminated in an accessible and engaging manner. One approach to strengthening restoration capacity is through “hands-on” field-based courses situated in diverse biophysical and socio-economic contexts that demonstrate the complex reality of human-dominated landscapes, where restoration activities are most critically needed. This presentation will describe the Environmental Leadership and Training Initiative’s (ELTI) approach to develop focal training sites in both the tropical wet and dry forest ecosystems in Panama to facilitate practical field-based forest restoration courses for a diversity of land-use decision-makers. In 2013, ELTI established the training sites in areas of long-term forest restoration research conducted by the Yale School of Forestry and Environmental Studies (F&ES) and Smithsonian Tropical Research Institute (STRI). To enable learning, ELTI developed demonstration areas, interpretive trail networks and model-farms, where data is synthesized and integrated into the course curriculum and training materials. Courses are facilitated by experts and designed to communicate restoration benefits in a culturally sensitive manner by integrating local landowners as co-facilitators of the course. ELTI’s approach of conducting field-based courses in focal training sites enables the understanding of restoration principals, engages participants with active exercises, illustrates the importance of science in decision-making and, as a result, empowers practitioners to initiate informed landscape restoration strategies.

S04.04 - Experimental research and demonstration sites in Southern Bahia, a living laboratory of forest conservation and restoration in Brazil

DANIEL PIOTTO

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Southern Bahia is known for its high levels of plant species diversity and endemism. Another interesting feature of the region is the diversity of land uses. Remnants of undisturbed mature forest and secondary forest share the landscape with cacao agroforestry systems, tree plantations, agricultural fields, pastures and degraded lands. This talk discusses the role of field-training sites to support education, research, training, and entrepreneurial activities related to sustainable rural development in southern Bahia. We present the recent efforts of ELTI to establish a set of long-term field-training sites in the region, in partnership with academia, NGOs, landholders and other stakeholder groups. These demonstration sites include permanent inventory plots of natural forests (mature and secondary) and human-modified forest systems such as native and exotic tree species plantations, agroforestry systems, home gardens as well as examples of the most common agricultural systems and degraded lands. Every demonstration site has detailed information about its land use history, disturbance regime, soil type, and vegetation. These sites are used for forest conservation and restoration training based on field exercises, interpretive trails, and customized teaching materials for every site. The network of sites includes private and public land and local people participate actively with the establishment and maintenance of the demonstration sites. Through this case, we highlight ability of field-training sites to serve as field laboratories for scientists and practitioners interested in ecological, social and economical aspects of forest conservation, restoration, and land use dynamics in the tropics.

S04.05 - Innovative online training tools for bringing field training experiences to researchers and restoration practitioners around the world

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Recent advances in technology along with the global expansion of internet access provide an unprecedented opportunity for the exchange of information on ecological restoration. Meanwhile, the growing involvement of diverse stakeholders researching and carrying out restoration on community, regional, and national levels necessitates improved dissemination of scientific findings and sharing of lessons learned. This presentation explores how online capacity building facilitates communication between experts, practitioners, researchers and other stakeholders by showcasing the practical experience from field training sites around the world. Since launching online training courses in 2013, the Environmental Leadership and Training Initiative (ELTI) has found new and innovative ways to create international case studies that share with participants the practical experiences, research results, and technical details of specific restoration initiatives. For these materials, the ELTI Online Training Program draws upon the lessons learned from research and implementation of restoration activities within the network of ELTI's field training sites in the Philippines and Panama, along with demonstration sites of ELTI's partners in Brazil, Colombia, Indonesia, Rwanda, and Sri Lanka. These materials have been featured in online courses in five different languages to restoration practitioners from over forty-five countries. By highlighting ELTI's experience developing and delivering these materials, we hope to shed light on the challenges and opportunities for using online media to share the lessons learned from particular training sites with researchers and practitioners across countries, regions, and continents.

S05 Governance, restoration, and degradation neutrality. Session 1: comparing drivers and integrating efforts worldwide

Organizer: Gustavo Zuleta

S05.01 - Conceptual framework: Integrating restoration, degradation neutrality, and human well-being. Can we do it possible?

GUSTAVO A. ZULETA; NARKIS MORALES

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Despite early warnings during the ´60s, right governance decisions during the ´70s, and the emergence of the ecological restoration (ER) 30 years ago, degradation of natural resources is still a relevant concern worldwide. About 70% of the terrestrial vegetation cover is currently modified from natural conditions (in some areas almost 100%). Many ecosystems require restoration or sustainable use to revert the trend. Fortunately, several international agreements promote restoration paradigms/efforts: Aichi goals, 20x20 initiative, Land Degradation Neutrality (LDN-UNCCD), ROAM-FAO, IPBES conceptual framework. The new context has rapid political effects: 106 countries have endorsed neutral degradation by 2030 (LDN main objective). At the continental-national-local level, however, decision-making is occurring at different speeds and commitments. Regions and countries like Europe, USA-Canada, Brazil or Australia have strong legislations, funding supports, and long-term knowledge to establish indicators and priorities. They differ on drivers (e.g. economic benefits), stakeholder interests, internal contrasts (Europe), or recent (2017) dilemmas (USA). Latin-America and the Caribbean region, has a high variation of governance efforts (public and private), distinctive drivers (ancestral knowledge of sustainable land use), and cultural similarities that facilitate cooperation. The “multiple Africas” are characterized by high restoration needs with low governance strengths and particular drivers (poverty alleviation). The “giant” Asia shows an intermediate pattern considering drivers, networking, priorities, and cultural differences. The aims of this symposium are to update discussions and analyses of global comparisons, and integrate methods and approaches to achieve our major responsibility: “balancing between socio-political interests (ensure human well-being) and socio-environmental interests (ensure resources availability)”.

S05.02 - Power relationships regulating the restoration of degraded habitats, territories and populations in Europe

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The European Union (EU) is an extensive territory with a huge variety of socio-ecological characteristics. Most conservation and restoration actions in the EU come after a number of legislation rules as the Water Framework, Habitat, Floods and Bird Directives which stimulate restoration actions. THE EU Life Program has been an excellent joint venture between local and state authorities for 25 years. NGOs, and scientific teams. However, strong differences of approaches and implementation of restoration are observed throughout Europe because of administrative, economic and social differences among the EU state members. While consolidated states in north and west Europe perform advanced restoration practices, newly incorporated countries in east Europe show differences and difficulties to develop restoration programs. NGOs and farmer Unions are important stakeholders with, respectively, direct interest or as assisting actions for productive uses of land. Local authorities are another group of interest with strong potential for restoration actions derived from their authority to regulate land cover and land uses. Major power capacity to stimulate and regulate restoration in Europe is based on the European Government. It is expected that the EU Governing bodies will continue figuring prominently in the power relationships for developing restoration at continental scale while economic and social integration of European human populations takes place in spite of recent initiatives as that of U.K. to become a non-EU state member.

S05.03 - Governance and drivers in the multiple Africas: Is ecological restoration feasible?

OLIVIER HAMERLYNCK; STÉPHANIE DUVAIL; WANJA D. NYINGI; QUENTIN LUKE; JEAN-LUC PAUL; GRAZIA BORRINI-FEYERABEND
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Restoration ecology science and practice are in their infancy in Africa. Interventions are driven by multinationals (e.g. World Bank funding compliance) and corporate responsibility under pressure from civil society in the North (e.g. rehabilitation of mining sites). Alternatively, they are donor-driven site-specific projects funded by North-based nature conservation. Legislations with stringent environmental and social impact assessment regulations exist, including post-project audits and restoration. However, such post-hoc evaluations are almost never conducted. National environmental agencies and civil society organizations lack of capacity e.g. in ecological engineering and in conducting participatory processes for restoration. Free Prior and Informed Consent (FPIC) is still virtually unknown and not incorporated in national legislations that are also not explicit on the rights of indigenous people and who should be recognized as such. The AICHI targets, the Sustainable Development Goals and the International Environmental Conventions, also in relation to expected funding to deal with climate change, remain almost entirely with a few individuals in government departments doing desk jobs. National visioning exercises are oriented towards infrastructure development according to a “modernity” paradigm rather than to the existing potential for restoration in biodiversity and ecosystem service delivery based on local needs and ecological knowledge to the benefit of, in particular, vulnerable groups. Communities wishing to initiate restoration projects, obviously small scale, will not go through national mechanisms but orient them towards environmental NGOs or small grant programs such as GEF. The situation is analyzed from a wider governance and ethics perspective.

S05.04 - Social Perspectives on Drivers for Restoration in North America

ANDREW SPAETH, STEPHEN R. EDWARDS

In the western United States, between 40% and 90% of any given county is in federal ownership and managed by the Forest Service, Bureau of Land Management, Fish and Wildlife Service, or National Park Service. The principal federal land management agency in the eleven western states is the US Forest Service, which manages 46.4% of the total land area. Historically, federal forestlands were the exclusive province of specialists in the agency, however; today, increasingly community-driven, collaborative natural resource governance is supporting and guiding land management planning. Federal legislation such as the National Forest Management Act (NFMA), National Environmental Policy Act (NEPA), and Collaborative Forest Landscape Restoration Act (CFLRA) require federal agencies to engage with a diverse public and integrate input into decision-making.

We explore the impact of these public policies and social processes on forest landscape restoration. Specifically, how these processes have evolved over the past 30 years and how diverse stakeholder participation influences decision-making and implementation. By using some internationally accepted standards, such as the Principles of the Ecosystem Approach that were adopted by the Parties to the Convention on Biological Diversity (2000 - Decision V/6), we find that increased stakeholder involvement has reduced conflict and increased levels of social capital and trust resulting in more governmental support, more opportunities to leverage new resources, and accelerated management planning and implementation, while increasing capacity to respond to stochastic events such as wildfires, which are expected to increase in intensity and severity.

S05.05 - Governance and drivers of ecological restoration in China

JUNGUO LIU

China is one of the earliest countries that carried out large-scale ecological restoration. The government will further strengthen the efforts in ecological restoration to ensure greener, more sustainable development, according to the 13th Five-Year Plan (2016-2020). A comprehensive review on the restoration projects is a key to providing important information to implement future projects. This talk will demonstrate the key restoration projects in China since the 1950s, show the achievements and challenges of ecological restoration, and analyze the governance and drivers of the restoration practice. China has experienced serious ecological degradation, and it is time to restore degraded ecosystems like wetlands, forests and soils. Special attention should be paid to enhancing biodiversity and improving ecosystem services of natural ecosystems. China has entered a new era of eco-civilization, and there is a huge demand for science and technology to achieve the targets of ecological restoration established by the government. It is of vital importance to strengthen collaborations among scientists, practitioners, and policy makers in near future.

S06 At the nexus of wetland restoration and climate adaptation: Trade-offs, targets, and trajectories

Organizer: Kate Ballantine

S06.01 - Braced for change, mindful of complexity, resisting ‘novelty’, committed to restoration

PADDY WOODWORTH

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Wetlands, like all other systems, will experience significant new stresses as climate changes, even if the current political shift in favour of fossil fuel lobbies can be rapidly reversed. If intact or restored, wetlands will also play a major role in reducing climate change impacts, through sequestering carbon, retaining water during extreme weather events, and the resilience of their biodiverse communities. This makes the ecological restoration of wetlands a greater imperative than ever. The challenge for ecological restorationists is to predict likely changes as far as possible, and respond to them with flexible strategies, while rigorously pursuing the target of restoring to historical trajectories and native communities that is the distinctive feature of our field. We should reject the fashionable ‘new conservation’ strategies that rebrand degraded ecosystems as ‘novel’. In my view, these strategies are the antithesis of restoration, and facilitate social acceptance of ecologically impoverished systems. Despite the new problems presented by climate change, these systems largely remain restorable where sufficient expertise, community engagement and resources are dedicated to the restoration enterprise. However, our commitment to restoration must be matched by humility about knowledge gaps in restoration ecology, and transparency about the complexity of the restoration process. We must beware the moral hazard of over-promising to mitigate climate change through post-restoration greenhouse gas sequestration on wetlands. For example, restored peatlands, while sequestering CO₂, may also increase methane emissions. This budget is complex. I will illustrate these points through case studies from my native Ireland, and international research.

S06.02 - Examining greenhouse gas flux responses to restoration

ROSE M. MARTIN; CATHLEEN WIGAND; KATE BALLANTINE

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Wetlands play an important role in the flux of greenhouse gases such as carbon dioxide, methane, and nitrous oxide. Wetland ecosystems are characterized by slow decomposition and, often, high productivity, making them net sinks of carbon dioxide. However, under some conditions, such as tidal restriction and nutrient pollution, wetland soils may act as sources of methane and nitrous oxide. Understanding impacts of wetland restoration projects on a site’s greenhouse gas flux dynamics may be of interest both as a gauge of a restored site’s functional equivalency and for use of carbon credits to fund restoration activities. In this talk, potential impacts of restoration on wetland greenhouse gas fluxes will be discussed with examples from studies in a variety of wetland systems. Examples include: Comparing greenhouse gas fluxes in a pre-restoration cranberry bog to those of nearby natural wetlands; testing effects of restored tidal hydrology on methane emissions in a tidal salt marsh; and examining impacts of invasive plant monoculture removal on carbon dioxide and methane emissions in a brackish marsh.

S06.03 - Long-term development and climate related ecosystem functions of restored freshwater wetlands

KATE BALLANTINE

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Just as principles from ecosystem science inform restoration practice, restoration practice can inform our understanding of ecosystems and guide future restoration projects. This presentation will summarize some of the basic and applied research we are doing in restored wetlands to investigate how these systems develop and function under different climatic conditions, and what restoration methodologies may stimulate desirable and undesirable ecosystem processes over the long term. Ongoing projects examine structural and functional development in wetlands ranging from 0 to 75 years since restoration, as well as the effects of soil amendments that range along a gradient of carbon lability (e.g., biochar, topsoil, compost, straw) on vegetative communities, greenhouse gas fluxes, water quality parameters, microbial community structure, and soil cycling of nutrients via soil microbial processes. New projects compare development trajectories under different management scenarios after agricultural use, including active cranberry farms, retired cranberry farms, restored cranberry farms, and natural reference systems. Controlled greenhouse experiments and complimentary field-scale manipulations are being implemented to illuminate the impact of climatic variables and soil amendments on development and function over time. Preliminary results will be presented.

S06.04 - Coastal wetland interior drowning: can it be reversed?

ELIZABETH WATSON; JOHANNES KRAUSE; KIRK RAPER; ELISABETH POWELL; WENLEY FERGUSON

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In New York and southern New England, USA, coastal wetlands are experiencing dramatic changes in extent due to fragmentation: marsh edges are eroding, channel networks are incising headward, and interior ponds are developing and expanding. Wetland losses appears to be due to the rapid rates of sea level rise in the region, in combination with conditions that increase vulnerability to sea level rise, such as highly altered hydrology, low sediment inputs, and poor water quality. Here we report on results of an experiment conducted in Narrow River, Rhode Island, to encourage revegetation of drowning marsh through strategic use of runnels to reduce groundwater levels. We explore issues surrounded marsh pond management, as it is an area where conflicting marsh management goals collide.

S06.05 - Coastal resilience planning in New York: Identifying places where vulnerable communities and conservation priorities intersect

NICOLE MAHER; MARCI BORTMAN; STEPHEN LLOYD

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Like many low lying coastal areas around the world, coastal areas in New York, USA are facing the very real and increasingly severe threat of sea level rise. New York is located along the northeastern US coast which has been identified as a “hotspot” for accelerated sea level rise where we anticipate sea level rise rates 3–4 times higher than the global average. Accelerated sea level rise is expected to exacerbate historic trends of coastal salt marsh loss and put increasing numbers of people and infrastructure in harm’s way. Our very populated coasts were developed before we appreciated the reality of rising sea levels, intensifying coastal storms and rising groundwater tables that are making these areas highly vulnerable to coastal storm events and increasingly subject to sunny-day flooding as well. The human wastewater associated with coastal development is also threatening the condition, function and long-term viability of our coastal habitats. Many times, places where people and infrastructure are at high risk are the same places that are ideal for natural migration or restoration of coastal habitats. We are working to identify locations that have both high vulnerability to climate threats (people and infrastructure at risk and wastewater causing environmental damage) and high conservation value (such as marsh migration or restoration potential) so that we can strategically plan for increased resilience of our coastal communities and natural habitats now and into the future.

S06.06 - A restoration framework to build coastal wetland resiliency

CATHLEEN WIGAND

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An increase in the frequency and intensity of storms and flooding events are adversely impacting coastal wetlands. Coastal wetlands provide flood abatement, carbon and nutrient sequestration, water quality maintenance, and habitat for fish, shellfish, and wildlife, including species of concern, such as the saltmarsh sparrow (*Ammodramus caudacutus*). A framework and methodology adopted by scientific, management, and policy stakeholders for restoration and adaptation actions to manage coastal marshes in Northeastern, USA is described. A traditional adaptive management approach was modified to identify extreme event vulnerabilities and propose adaptation actions to build coastal resiliency. When possible an experimental BACI (Before-After, Control-Impact) design was incorporated into the implementation plans. Specific adaptation actions and monitoring plans are described, and include protecting marsh shoreline, restoring hydrological drainage patterns, increasing marsh elevation, and enabling upland marsh migration. The restoration framework is presented as a demonstration of adaptation actions to build coastal resiliency in tidal marsh systems subject to extreme weather events.

S07 Restoration of ecosystem functions and processes: how far have we come?

Organizer: Young D. Choi

S07.01 - Attributes of ecosystem functions and ecological processes: a lesson from grassland restoration in the US Midwest

YOUNG D. CHOI

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Ecological processes and ecosystem functions are among the key measure for successfully restored ecosystems. The attributes of ecosystem function may include but not limited to sequestration and transformation of energy, elements and moisture. Biotic interactions, microclimate control and substrate stabilization are examples of attributes for ecological processes. Measurements of such attributes are often time-consuming and challenging. In Taltree Arboretum, located in the US Midwest, a restored grassland attained higher diversity of plant species than a nearby old field. The enhanced plant species diversity appeared to increase primary production for a certain period of time in the restored prairie. However, the raised productivity did not lead to carbon sequestration measurably in soil 15 years after the restoration. There was no statistically significant difference in the rate of litter decomposition between the restored prairie and the old field. Abundance of detritivore- and scavenger-arthropods were also not different between the two sites. The prairie restoration did not increase the diversity of arthropod families, however it has likely facilitated the potentials for herbivory and pollination by the arthropods as reflected by their abundance. In this restoration, the “bottom-up” control by establishing native plant assemblage was limited to only a few attributes such as primary production, herbivory and pollination during the first two decades after the restoration. Measurement of other attributes, such as soil carbon sequestration and biotic interactions at predator level may require a longer period of time.

S07.02 - Inferring functions from structure in assessing wetland restoration outcomes

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We question the concept that restoration of diverse native plantings (vegetation structure) will provide desired ecosystem functions. We hypothesize 1st that the actual structure of restored wetland plant communities will differ substantially from what was planted and 2nd that diversity will not necessarily predict functional outcomes. Having monitored structure and function in two USA wetland creation projects (a tidal marsh in Tijuana Estuary, CA, and urban-runoff swales in Madison, WI) we found that planted diversity declined in both sites within three years. Each site shifted toward a single dominant that occupied >80% of sampled plots and contributed >50% of plant biomass, supporting our 1st hypothesis. In Tijuana Estuary, productivity and N-uptake were high, an outcome driven by dominant species rather than diversity, supporting our 2nd hypothesis. Our swales showed the same pattern, with monotypic vegetation out-producing diverse vegetation. But because we also measured hydroperiods, we were able to identify hydrologic regime as the primary driver of six ecosystem functions, supporting our 2nd hypothesis. Prolonged hydroperiod mobilized N&P and favored tall productive monotypes, making vegetation structure more of a response than a driver of function. Shorter hydroperiods (and greater infiltration of urban runoff) enhanced plant diversity, water quality improvement, and flood abatement functions. A revised model of structure-function relationships in nutrient-rich wetland restoration sites would focus on likely dominants, and use them to indicate hydrological conditions that control functions. Results from the swales highlight the need for more direct measurement of ecosystem functions—in search of cause-effect relationships and regional indicators.

S07.03 - Can wetland restoration from cropland restore the function of carbon sequestration?

HUA CHEN

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Wetland restoration has become increasingly important, especially after the implementation of USDA the Conservation Reserve Program (CRP) and the Wetland Reserve Program (WRP). A majority of the early research and practices of wetland restoration have focused on the structural aspects (e.g., site preparation and reintroduction of specie assemblage) of ecosystem. The ecological functions of restored wetlands from croplands, such as carbon (C) sequestration, have only been reported occasionally. The overall goal of this study was to review C sequestration of the restored wetlands from croplands in United States by focusing on soil organic matter (SOM). In addition, I examined organic C dynamics of aboveground plant biomass in restored wetlands. In this review, time since restoration and type of restored wetlands are two key determinants that influence C sequestration of the restored wetlands. The key case studies in this review include restored wetlands in central New York, Illinois, and western US. All these studies indicated that restored wetlands can enhance the function of C sequestration over time, especially in SOM. However, the rate of C accumulation of the restored wetlands was influenced by many other factors. This review also suggests that that restored wetlands have potential to sequester more C in future after comparing with C sequestration of reference wetlands.

S07.04 - Acoustic monitoring: A powerful tool for evaluating fauna recovery in restoration projects.

T. MITCHELL AIDE

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There is an urgent need to increase the temporal and spatial coverage of ecological data collection in response to anthropogenic threats to global biodiversity. Acoustic monitoring can help us improve our ability to monitor population change in thousands of species, but the ecological, conservation, and restoration communities have been slow in incorporating this technology. During the last ten years, we have developed the Automated Remote Biodiversity Monitoring Network (ARBIMON), and we have demonstrated how inexpensive monitoring stations can collect a continuous stream of biodiversity acoustic data. These data can be uploaded, processed, and stored in the cloud and these data can easily be shared with colleagues around the world. Furthermore, analytical tools have been developed for soundscape analyses and species-specific identification models. This technology can provide detailed and long-term data for monitoring the fauna around the globe. For example, I will show how the elevation distribution of amphibians in Puerto Rico has changed over the last 30 years, presumably due to climate change. In addition, I will compare the soundscapes of nine tropical forest sites, and show that the total frequency/time use is highly correlated with total amphibian, bird, insect, and mammal richness. These examples demonstrate the power of acoustic monitoring for population and community level analyses, particularly in the context of restoration ecology. The challenge is convincing the restoration community that the cost/benefit ratio of this approach merits a shift in the limited funds available for biodiversity monitoring.

S07.05 - Anthropogenic ecosystem disturbance and the recovery debt

DAVID MORENO MATEOS; EDWARD BARBIER; PETER C. JONES; HOLLY JONES; JAMES ARONSON; JOSÉ A. LÓPEZ LÓPEZ; MICHELLE MCCRACKIN; PAULA MELI; DANIEL MONTOYA; JOSE MARÍA REY BENAYAS

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Ecosystem recovery from anthropogenic disturbances, either without human intervention or assisted by ecological restoration, is increasingly occurring worldwide. As ecosystems progress through recovery, it is important to estimate any resulting deficit in biodiversity and functions. We present results from 3,035 sampling plots worldwide to quantify the interim reduction of biodiversity and functions occurring during the recovery process. We call this loss the “recovery debt”. Compared to reference undisturbed levels, recovering ecosystems run annual deficits of 46-51% for organism abundance, 27-33% for species diversity, 32-42% for carbon cycling, and 31-41% for nitrogen cycling. Our results are consistent across biomes but not across degrading factors. Eutrophication and mining accumulated the highest debts. Our results suggest that recovering and restored ecosystems have less abundance, diversity, and cycling of carbon and nitrogen than undisturbed ecosystems and that even if complete recovery is

reached, an interim recovery debt will accumulate. Under such circumstances, increasing the quantity of less-functional ecosystems through ecological restoration and biodiversity offsetting programs are inadequate alternatives to ecosystem protection.

008 Mitigation: Mining

008.01 Relevance of International standards for the global mining sector

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This presentation will highlight some of the key advances in planning and restoration/rehabilitation implementation that have resulted in industry leading recovery outcomes from a corporate global business. This point is illustrated by the case study involving restoration of Banksia woodland vegetation after sand extraction on the Swan Coastal Plain, Perth Western Australia where a major priority of the company is to restore the post-sand extracted sites with a plant community closely resembling the pre-sand extracted Banksia woodland plant community. Collaboration between the sand extraction company and Kings Park & Botanic Garden over the past 22 years has enabled to development of procedures to ensure 75% of species return in restoration sites, despite sand extraction reducing the resultant sand profile depth by at least 20m. The research is now contributing to restoration practices worldwide with the techniques and technologies developed in the nutrient poor soils on the Swan Coastal Plain being adopted in work Kings Park are now undertaking in many countries including New Caledonia and Saudi Arabia, where the aim is to develop a high level strategy to restore the entire country. We show that a corporate companies' policy of 'doing it right and beyond compliance' has substantially improved outcomes from any other approach which might have been taken. We discuss how International Standards for the Practice of Ecological Restoration globally (which draw on the corporate lessons learned) will assist other companies achieve best practice restoration/rehabilitation and comment on how international standards might lead to improved practices and outcomes in other countries.

008.02 Montana Moonscapes: Innovations in erosion control on steep slopes of the Anaconda, Montana Superfund site

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Smelting activities in Anaconda, MT from the late 1800's to 1980 created a persistent aerial plume of contaminants that settled on the landscape, with devastating impacts on upland vegetation. Coupled with extensive logging to build mining infrastructure and fuel the first smelters, upland areas near the continental divide on certain soil types have been void of vegetation (including weeds) for nearly 100 years. Gully erosion of impressive scale developed a network of sediment delivery superhighways. Landscape-scale assessment, prioritization and remedy/restoration demonstration projects have been undertaken over the past 5 years to reverse the sediment imbalance and restore native vegetation to the roadless portions of the injured areas within the Mt. Haggin Wildlife Management Area. Soil amendment trials, innovative sediment catchment BMPs and natural sediment capture and storage techniques have been refined and scaled over the years, coupled with state-of-the-art unmanned aerial system (UAS) technology for long-term monitoring. Variations in geologic parent material, soil characteristics, topography and surface roughness will be discussed and encouraging results from sediment retention and vegetation enhancement projects will be illustrated.

008.03 Increasing knowledge on forest restoration and mercury contamination in areas degraded by gold mining in the Peruvian Amazon

FRANCE CABANILLAS; FREDY POLO; JUANA LLACSAHUANGA; MARTÍN PILLACA; JESÚS ALFEREZ; GABRIEL VELÁSQUEZ; DAVID LEFEBVRE; CLAUDIA VEGA; JULIO ARAUJO; RONALD CORVERA; CESAR ASCORRA; MILES SILMAN; LUIS FERNANDEZ

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During the last decade, gold mining grew significantly in Amazonian countries (Brazil, Peru, Ecuador, Colombia, Surinam, Guyana) becoming a major driver for land degradation and heavy metal contamination. In Madre de Dios, one of the highest biodiversity regions on Earth, large expanses of virgin rainforest are being transformed into denuded and mercury-poisoned wastelands, presenting severe limitations for natural regeneration and forest restoration.

In collaboration with local governments, research institutions, and informal gold miners, our project is installing local mercury analytic capability and establishing 42 hectares of experimental reforestation plots across the region affected by gold mining in order to: (1) evaluate the level of soil degradation and mercury contamination; and (2) assess the experimental establishment of 30-40 native tree species in abandoned mines.

Our project is increasing significantly the number of candidate species for reforestation in abandoned mines, while a reference framework for ecosystem restoration and remediation is being built through an extensive regional sampling effort on soils, water bodies, as well as on intact and regenerated forest stands. Effectiveness of biochar amendments are being tested for improving soil properties while preventing plant mercury contamination in reforestation plots. Drones are being used for characterization of degraded areas and for planning reforestation field experiments across the landscape.

To date, technical and scientific local capacities for restoration and remediation have been improved seriously through the installation of a mercury lab, a pirolizer for continuous biochar production, drone facilities, a high-tech nursery for seedling propagation, and the first 8 ha of reforestation experimental plots.

008.04 Soil reconstruction on reclaimed post mine sites in temperate zone versus tree species response - the key issues for reforestation challenges

MARCIN PIETRZYKOWSKI

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Post-mining landscapes are examples of a large scale transformation and human disturbance to ecosystem and reclamation has the worldwide interest and concern. In Europe, especially, coal and lignite still play a key role in the energy mix. Large portion of post-mining sites were reforested. A main objective of forest restoration at post-mining sites is establishing a long-term sustainable ecosystem, which depends on adaptations of tree species to newly-formed reclaimed mine soils, which are characterized by highly changeable chemical and physical soil properties and the consequential large spatial variability in habitat conditions. Thus in recent years, interest in tree species selection and their adaptation to post-mining sites has grown. The work presents consequences of mining extraction and reclamation managements with special focus on diversity of mine sites and soil-substrates affected degree of reclamation difficulties. An example of soil reconstruction techniques, variation of mine soils and reclaimed sites for reforestation and forest management were discussed with connection to tree species response and selection. Tree species response is exemplified by studies with a special focus on common species on reclaimed mine sites in central and eastern Europe as Scots pine, European larch, European oak and alders. Trees growth and morphology, biomass, root system reaction, macronutrients supply were exemplified. Some remarks and conclusions and the perspective of future studies are presented, as well.

008.05 Development and Application of a Resilience Model for Socio-Ecological Restoration in the Mining Sector

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In the last 10-15 years, there has been a proliferation of models to assess community disaster resilience (CDR) and application of these models for disaster risk management. Many of the models and applications have been criticized for lacking adequate assessment tools by which the effectiveness of the resilience models can be evaluated. Other critiques have focused on the interdependence and overlap created by how models define domains, indicators, and indices. The authors present a brief overview of CDR models and propose a CDR model framework for assessing and optimizing socio-environmental and socio-economic restoration actions applied for the failure mine tailings dams. To achieve the systematic operationalization of a CDR model applicable to the recovery of ecology and communities in the watershed, community and environmental disaster resilience indicators are classified into four domains: Socio-Political and Governance (e.g., culture, tourism, recreation, rural communities, and indigenous and traditional peoples); Physical (urban and rural reconstruction, water, wastewater, and energy); Natural Capital (aquatic and terrestrial ecosystems); and, Economic (livelihoods, education, and public health). Indicators for each domain are presented and discussed in terms of their relevance to the restoration program that can be implemented over impacted areas such as rivers, estuaries and coastline. An approach to review and optimize the different restoration actions will be discussed, as well as the likely path forward involving adaptive management as new information and experience evolves to achieve transformation, long-term sustainability, and health of the ecosystems and communities affected by mine disasters.

008.06 Restoring Banded Iron Formations after iron ore mining: ecophysiology and ecohydrological views

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Creating healthy and resilient ecosystems on recently disturbed sites to mitigate long-term impacts of mining activities is particularly challenging for Banded Iron Formations (BIF) mining and rehabilitation operations where (1) there is limited knowledge of substrate-plant-water interactions of intact systems and (2) newly created substrates do not have traits that correspond to the reference system. To increase confidence in restoring BIF ecosystems we used a combination of ecophysiological (gas exchange, chlorophyll fluorescence and leaf water potential) and ecohydrological (Electrical resistivity tomography - ERT) measurements to assess rehabilitation performance compared to reference system functioning. We hypothesised that plants on rehabilitated substrates will be less resilient (more susceptible) to severe drought stress during summer due to (1) altered soil water distribution and more rapid drying patterns of rehabilitated soil profiles and (2) juvenile plants on rehabilitated mine sites having more limited access to soil water given a shallower root system compared to mature plants on reference substrates. We found that the plants on the rehabilitated sites experienced lower levels of drought stress and were more active through summer compared to the reference sites. ERT measurements revealed that the soil profiles (5-12m) are highly heterogeneous but indicate that juvenile plants have access to a larger soil volume than mature plants on the shallow soils of BIF reference sites. Using soil hydrological and plant physiological techniques highlights that we may have greater confidence that restoration of these systems is possible and this approach should be considered as part of informing resilience more broadly.

009 Restoration of coastal aquatic ecosystems: science and practice

009.01 - Foundations of kelp forest restoration PART I: Resilience, environment-engineer feedbacks and habitat mosaics

CAYNE LEYTON; VICTOR SHELAMOFF; MASAYUKI TATSUMI; MATTHEW CAMERON; JEFFREY WRIGHT; CRAIG JOHNSON

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Ecklonia radiata is the most widespread habitat-forming kelp in Australasia. The underwater forests created by this ecosystem-engineer provide structurally complex habitats that support extremely productive and biodiverse communities. However, in numerous places globally kelp forests are declining, with habitat degradation causing increased patchiness and sparsity of kelp. Restoring degraded habitats may help conserve these ecosystems, however successful restoration requires a thorough understanding of kelp demography and resilience. In a world first, we created an array of 28 artificial reefs of different sizes covering 1.6 ha and supporting >500 adult kelp transplanted at a range of densities. We examined (i) how the physical environment within kelp forests changes with variations in patch size and kelp density and (ii) how these changes feedback to affect the demography and resilience of the kelp itself. Reductions in patch size and kelp density significantly increased irradiance, sedimentation and water flow beneath the canopy. These changes dramatically influenced the growth and survivorship of juvenile kelp, and determined whether transplanted kelp were self-sustaining. Additionally, different kelp densities facilitated distinct demographic processes, suggesting the mosaic of densities in a kelp forest is beneficial. For example, patches of low and high kelp density facilitated the growth of juveniles and the settlement of propagules respectively. Ultimately, healthy kelp forests facilitate their resilience by modifying the sub-canopy environment in a manner that benefits the next generation. Consequently, the creation of these positive-feedbacks, along with a variety of kelp densities, should optimise the likelihood of success in restoring kelp forests.

009.02 - Foundations of kelp forest restoration PART II: Habitat structure modifies community establishment

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Kelp forests create complex physical structure and environmental conditions that provide the foundation for extremely productive and biodiverse communities. These assemblages manifest a suite of processes that act to promote the resilience of kelp systems. Re-establishing these important processes is therefore an integral part of effective kelp forest restoration. We established an array of 28 artificial reefs supporting transplants of Australia's most abundant kelp species (*Ecklonia radiata*). We used the array to determine the separate and combined effects of different patch sizes and kelp densities on key aspects of community dynamics, including: i) secondary production, ii) the structure of understory algal and invertebrate assemblages, and iii) the structure of fish and macro-invertebrate assemblages. Secondary production associated with benthic rope-fibre habitats declined with increasing reef size and kelp density. In contrast, the abundance and diversity of understory algae increased with reef size and distinctly different assemblages formed beneath different canopy densities. Larger reefs also supported a greater density and diversity of fish and a greater abundance and diversity of macro-invertebrates, and again different species were associated with different kelp densities. Additionally, larger reefs with low and natural kelp densities supported the establishment of very dense oysters mats (*Ostrea angasi*) and had highest recruitment of southern rock lobsters (*Jasus edwardsii*). It is clear that the structural characteristics of kelp populations have significant consequences for the establishment of other associated species. Manipulating the configuration of restored kelp habitat may be effective in enhancing mechanisms that increase the resilience of these important systems.

009.03 - Evaluation procedure of the rehabilitation of the nursery function inside harbors of a large marine protected area

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Littoral urbanization caused by the proliferation of coastal infrastructures is a main issue for marine organisms. Because they are localized in sheltered and shallow areas, these infrastructures inevitably lead to the loss of essential natural habitats once used as nurseries by juveniles. The objective of this program was to rehabilitate the nursery function inside Mediterranean harbors by giving fish juveniles a substitute to natural rocky habitat. Harbors' docks and pontoons 3D structure was complexified by the addition of small artificial units. The study was led in the Gulf of Lion Marine Park with the idea of integrating conservation and restoration for the common goal of preserving biodiversity. Evaluating the efficiency of the approach was challenging, as the nursery function is temporally highly variable and species dependent. We implemented a Before After Control Impact protocol (BACI) for two years (2015 and 2016), juvenile fish being numbered and sized every month between April and November. Two harbors were used as a Control landmark, two natural sites as Reference and two harbors were rehabilitated on the second year. This protocol allowed us to integer the natural variability of juveniles' settlement and thereby to get an accurate idea on the effect of the large deployment of artificial habitats. Rehabilitated sites showed increased diversity and densities compared to Control and equivalent to those found in natural sites. They even seem to enhance the settlement of some relatively rare species. These results suggest that nurseries rehabilitation inside harbors may be a good complementary tool to conservation in large protected areas.

009.04 - The Cayman Islands Coral Reef Restoration Explorer: Guiding restoration through multiple ecosystem service benefits

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The Cayman Islands Coral Reef Restoration Explorer utilizes multiple models of ecosystem services provided by Coral Reef ecosystems to guide restoration efforts to maximize these services. The ecosystem services models include: tourism, coral connectivity and coastal defense. The Restoration Explorer allows for the planning of coral and mangrove restoration with the focus on enhancing a particular environmental service. The tourism model data represents the number of Photo User Days (PUDs) to estimate the amount of recreation and tourism occurring around the Cayman Islands. The resulting analysis gives an indication of the areas that are most important for tourism. The coral connectivity model used NOAA's Real Time Ocean Forecasting System (RTOFS) ocean circulation model and regional coral reef data to simulate eight coral spawning events from 2008-2011, applying a 30-day pelagic larval duration and 20% mortality rate. Larval dispersal patterns were analyzed between reef units across jurisdictional marine zones in order to identify spatial relationships between larval sources and destinations within countries and territories across the region. Ocean current data were acquired from the NOAA. The Coastal Defense model uses standard engineering techniques to help users estimate how and where to restore or conserve critical habitat, reducing wave impacts and increasing the resilience of the local community and infrastructure.

S10 Using non-local plants for restoration: fallacy or fundamental?

Organizers: Anna Bucharova and Martin Breed

S10.01 - Alternative provenancing strategies, theory and empirical evidence

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Supplying appropriate plants is a crucial first step for restoration. Many plant populations are being challenged to adapt or disperse rapidly enough to keep pace with climate change. Therefore, it has been argued that it is unwise to only use local plants for restoration. In this talk, I will outline the arguments for alternative provenancing strategies, from a theoretical perspective. I will then case study empirical evidence for or against these alternatives from several Australian provenance trials.

S10.02 - Climate adaptation and provenance choice for ecological restoration: Insights from Eucalyptus

BRAD POTTS; PETER HARRISON; TANYA BAILEY; AKIRA WELLER-WONG; BENJAMIN GOSNEY; JULIANNE O'REILLY-WAPSTRA; NEIL DAVIDSON; DOROTHY STEANE; RENÉ VAILLANCOURT

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In many cases, local plant species are predicted to be maladapted under future climate projections and the restoration paradigm that 'local-is-best' is being increasingly questioned at both species and provenance levels. A number of recently proposed seed sourcing (provenancing) strategies have suggested capitalizing on the inherent genetic diversity and adaptive capacity within native species to increase the long-term resilience of restoration plantings. Testing of these strategies before wide deployment by practitioners is important. We here present results from pedigreed eucalypt provenance trials embedded within large-scale tree plantings for restoration purposes across a highly modified rural landscape on the island of Tasmania, Australia. Over the last six years, these common-garden trials have been established at ten sites using multiple provenances of five eucalypt species. These trials are linked to studies of provenance differentiation in functional traits and molecular markers. The trials aim to (i) test local versus non-local provenance performance (i.e. survival, growth, reproduction), (ii) model provenance performance and trait variation as functions of home-site climate and other factors, (iii) determine whether there is genetic variation within local populations to allow adaptation, and (iv) determine the impact of non-local provenances on dependent organisms. Early field trial results have revealed provenance differentiation in most fitness-related traits; however, the relative performance of local provenances appears to be context dependent and may vary between species and location of the trial site within the species' range. These early findings are refining our species and provenance choice strategies and helping to guide future restoration projects.

S10.03 - No restoration benefit from climate-adjusted provenancing of banksias - evidence from large-scale, multi-year provenance trials

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Decisions on the source of seed can have significant impacts on the success of ecological restoration. "Local is best" is a widely accepted benchmark and starting point. Numerous alternative strategies have recently been proposed. A key concern is climate change, and "climate-adjusted" seed sourcing has been advanced as a solution. However, few empirical tests of the various sourcing strategies exist, especially in an ecological restoration, rather than forestry, context. Reciprocal provenance trials are powerful tools to assess fitness and the relative merits of these seed sourcing strategies. Here, I present results from a large-scale trial with *Banksia menziesii*, a key species in the restoration of *Banksia* woodland. In total, 24,000 seed sourced from 24

sites from across the distribution of *B. menziesii* were sown into 3 provenance trial sites in each of 2 years (2013 and 2015). Seed germination and plant survival to 6 months were measured at each site and year, and assessed against climate distance between source and trial sites. In each site and year, the performance of seed sourced from hotter/drier sites was less than those from cooler/wetter sites, despite climatic conditions at trial sites that was expected to benefit seed adapted to hotter/drier conditions. The recovery of whole 9-month old plants from post-mining sandy soils in 2013 enabled an accurate measure of total (above- and below-ground) plant biomass. These data showed strong support for the “local is best” seed sourcing strategy. In each case, there was no evidence in support of benefits from climate-adjusted seed sourcing.

S10.04 - Are local plants the best for ecosystem restoration? It depends on how you analyze the data.

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The debate on origin of seeds for restoration largely depends on evidence for local adaptation. This evidence is inconsistent, partly due to different experimental approaches that have been used to test for local adaptation. We illustrate how conclusions about local adaptation depend on the experimental design and in particular the method of data analysis. We used data from a multispecies reciprocal transplant experiment and analyzed them in three different ways: (1) comparing local versus foreign plants within species and sites, corresponding to tests of the “local is best” paradigm in ecological restoration, (2) comparing sympatric versus allopatric populations across sites but within species, and (3) comparing sympatric and allopatric populations across multiple species. These different approaches are related to different experimental designs. While a local versus foreign comparison can be done even in small experiments with a single species and site, the other two approaches require a reciprocal transplant experiment with one or multiple species, respectively. The three different analyses led to contrasting results. While the first approach indicated lack of local adaptation or even maladaptation, the second one rather suggested local adaptation, and the third test provided significant evidence for local adaptation. We demonstrate how the design of experiments and methods of data analysis impact our conclusions on the presence or absence of local adaptation. While single-site experiments may be useful for identifying the appropriate seed material for a specific restoration project, general patterns can only be detected with reciprocal transplant experiments with multiple species and sites.

S10.05 - Consequences of plant ecotype introductions for biotic interactions

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The use of local provenance of plant material in ecological restoration is recommended because local genotypes should be better adapted to local environmental conditions. Often abiotic conditions such as climate and soil are cited as major drivers of local adaptation. However, plants may also be adapted to local biotic factors such as plant communities, herbivores, pathogens, mutualists, soil organisms, etc. Although less well understood than the influence of abiotic factors on local adaptation, spatial variation in biotic factors and their influence on plant fitness very likely result in local adaptation to the biotic environment. On the other hand, associated organisms may also be locally adapted to local plant genotypes leading to a coevolutionary “arm’s race” between local plant adaptation and local adaptation of those organisms. The introduction of non-local plant material changes the balance between adaptation of plants and other organisms. Consequently, such plant introductions may increase or reduce the performance of associated organisms.

We will present scientific studies testing the interactions between plant genotypes and antagonists such as herbivores and pathogens. The results confirm in some cases a contribution of antagonists to local plant adaptation resulting in an increase of abundance and damage on introduced plants. In other cases, antagonist adaptation prevail and non-local plants showed a lower abundance of such associated organisms. Although it seems to be difficult to predict the direction of changes compared with local plant populations, nearly all plant introductions resulted in a significant change in interactions affecting ecosystem functions.

S10.06 - Is local best? A 60 year assessment of provenance trials in Australia

MARTIN F. BREED; PETER A. HARRISON; REBECCA JORDAN; PAUL RYMER; DOROTHY STEANE; LINDA BROADHURST; DAVID BUSH; DAVID LEE; MARGARET BYRNE; DAVE COATES; NICK J.C. GELLIE; NOLA HANCOCK; SIEGY KRAUSSK; MAURIZIO ROSSETTO; BRAD M. POTTS; ANDREW J. LOWE

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In many cases, local plant provenances are predicted to be at risk of maladaptation under future climates and the restoration paradigm that local-is-best is being increasingly questioned. We here review the impact of climate on provenance performance in 248 historic trials of 83 Australian woody plant species established in Australia between 1964 and 2015. The number of provenances per species tested in any given trial ranged from 2 to 62. We tested the local-is-best paradigm and modelled the relative performance of a provenance using two fitness surrogates (survival and growth) against the deviation of their historic home-site climate from the climate experienced during the trial growing period. While local provenances tended to be above the median performance, they were no more repres

S11 Social and biological considerations in establishing an effective native plant nursery program

Organizers: Anthony S. Davis and Jeremiah R Pinto

S11.01 - Fostering communication across native plant nurseries: The Intertribal Nursery Council

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Since 2001, the Reforestation, Nurseries, and Genetic Resources (RNGR) team of the USDA Forest Service has emphasized outreach to Native American Tribes in order to learn and foster long-term collaborations focusing on native plants, nurseries, and educational activities. In this timeframe, RNGR has learned that Native Americans are working not only to manage their land, but also to preserve their traditional ecological knowledge, and to develop and enhance production of native plants for spiritual, medicinal, cultural, educational, and land restoration uses. To aid this, RNGR developed a special Tribal Nursery Emphasis program to work effectively across the diverse needs of tribes. This program 1) delivers ongoing technical assistance to Tribes about collection, propagation, and deployment of native plants, 2) organizes the Intertribal Nursery Council, an annual forum for tribal members to gather and discuss important topics relevant to native plants and culture, and 3) provides detailed guidance in nursery development and native plant propagation as it relates to Tribes. To date, the RNGR Tribal Nursery Emphasis has assisted many tribes across the US, Canada and Mexico and has worked one-on-one with hundreds of tribal professionals. This assistance has included various nursery training workshops, information sharing meetings, technical assistance, and other projects that enhance conservation education, promote restoration, and provide opportunities for elders to interact with children and share traditional ecological knowledge. This presentation will highlight the challenges, uniqueness, and successes of working across diverse cultural areas (specifically related to the RNGR program) in order to achieve diverse restoration goals.

S11.02 - Incorporating technology into nursery programs and creating a pathway for increased community participation

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Haiti was once considered the Pearl of the Antilles, a biologically rich and geographically diverse country that quickly transformed into a major economic driver of Napoleonic France. Following the revolution that led to independence, natural resources in the country were progressively depleted in an effort to make debt payments and support local needs. These practices led to Haiti being one of the world's most deforested countries. Continuous pressure has only served to maintain, or even increase, these pressures. Efforts to ameliorate this have been made through numerous reforestation projects with varying degrees of success. While gains have been made in agronomic production, relatively little work has been conducted in the native plant production component. This focus is needed to conserve endangered species including the endemic *Pinus occidentalis*, a high-mountain, five-needle pine that serves as a core component of myriad avian and mammalian habitats. Using a community-based, capacity-building approach, this partnership network has embraced a mix of research and technology transfer in a real-time effort to help arrest the trend of native forest cover loss. In 2015, a small native plant nursery was established in Kenscoff, Haiti with the aims of a) using science-based methods to provide high quality seedlings for restoration of degraded forest conditions and b) serving as the base for women to learn about plant biology, water and soil conservation, and environmental stewardship in an informal, collaborative setting. This presentation highlights some of the steps taken in capacity-building, community engagement, and addressing challenges in the project to date.

S11.03 - Establishing a science-based native plant nursery in Togo

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Togo is a small, tropical country in West Africa that has lost more than half of its forested area since 1990 due to slash and burn agriculture and fuelwood harvesting. In Togo, forests are culturally significant, essential for maintaining watershed health and preventing erosion and desertification, and a source of small-scale rural income. Forested ecosystems in Togo remain under

substantial threat with 5.75% of forested area lost annually. Limiting factors to reforestation success and benefits include monoculture agroforestry practices and low seedling survival; both of which underscore a lack of local knowledge of best-practices regarding natural resource stewardship. Through a project aimed at capacity building in a rural community, we established a native plant nursery and led science-based nursery workshops in Notsé. This project emphasizes building local partnerships with public and private organizations, incorporating local knowledge, and promoting project visibility through educational outreach, tours, and NGO trainings. Within the first nine months of the project, the nursery grew over 5000 seedlings, expanded to twice that of its initial size, and an experimental outplanting site has been established to monitor the success of the seedlings produced. Working from a limited budget and engaging a dedicated team of student volunteers as well as combining a scientific approach with a focus on community engagement, this project built local support and created a foundation for successful plant regeneration, conservation, education, and restoration. This presentation shares that experience and highlights some challenges and successes of this approach.

S11.04 - Community nurseries as novel model for rangeland rehabilitation in Jordan

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Rangelands compose more than 80% of Jordan's area and are vital for rural community livelihoods and groundwater aquifer recharge. Years of overexploitation, harsh environmental conditions, and regional conflicts, have severely degraded rangelands. Rangeland rehabilitation is national priority for provision of those economic and ecological benefits. Millions of rangeland shrubs have been planted yet these efforts suffer from extremely low seedling survival. Poor seedling quality was identified as the major challenge. The Sustainable Environment and Economic Development (SEED) project focuses on reviewing and improving techniques for propagating rangeland native seedlings to increase the survival of planted seedlings. SEED established a community-based nursery in Sabha (northern Jordan Badia) in cooperation with local partners, to produce high quality seedlings using science-based methods. The nursery team consists of six women with no agricultural background who have undergone an intensive capacity building program on theoretical principles of science and math related to seedling propagation; they have quickly developed and applied the skills needed to propagate thousands of quality seedlings. This demonstrates a novel approach for sustainable rangeland rehabilitation by engaging local communities in rehabilitation efforts and providing increased environmental literacy to enhance the stewardship of local resources. In addition to benefiting directly from jobs and providing seedlings, the nurserywomen have become strong advocates within their families and communities for natural area conservation and rangeland rehabilitation. They, and future nursery teams, are expected to spread the word on how local women changed the face of rangeland rehabilitation for the benefit of local communities in Jordan.

012 Ecological filters in restoration ecology

012.01 - Look down – there is a gap – need to include soil data in restoration projects in Atlantic Forest of Brazil

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There is an increasing number of restoration projects in Brazil and elsewhere, yet some of these initiatives are not successful due to a range of reasons. Among environmental reasons soil conditions may be a limiting factor. However, there is a scarcity of scientific studies analysing or even reporting restoration projects along with physical and chemical properties of soil. In most cases, the emphasis is given on the above characteristics of vegetation and below-ground part of the restoration project is under-reported. In this study, we carried out a systematic literature review to evaluate the extent of the data gap (and which data) regarding soil characteristics in restoration projects in the Atlantic Forest Biome (Brazil). Of 152 retrieved articles and theses, 41% (N =62) did not present any information on soil variables. The majority of the published works (71%) reported the information on pH while 66% presented information on potassium. The least reported variables were water retention (6%) and soil seed bank (3%). Most of the studies (60%) did not include any information on the reference area. This may have serious consequences for appropriate evaluation of the restoration success and its impacts on ecosystem services. Interestingly, studies that reported the reference area, the frequency on soil data reported changed with data on carbon being reported more frequently. This study highlights the gap that exists in sampling and analyzing soil data in restoration projects and its possible consequences on restoration success.

012.02 - Riparian Atlantic Forest restoration: water table depth and planting spacing affected the growth of planted trees

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In researches concerning the restoration of the Atlantic Forest floodplain, tree species development is affected by water table fluctuation. Thus, there is a need to investigate how the common species used to restore Atlantic Forest respond to water table fluctuation, and how it affects the success of restoration plantings. We measured tree species growth and water table depth in a five years restoration site in riparian Atlantic Forest, in order to verify the effects of water table fluctuation on the planted species development. We used the spatial interpolation method (Kriging) to interpolate the water table values on each 0.5 x 0.5 m of the experimental area, and used these values, as well as planting spacing (distance between trees), as predictors of total growth in OLS models. We checked the model premises and verified spatial autocorrelation. We added MEMs (Moran's Eigenvector Maps) to the model when necessary. There was a clear spatial pattern of water table fluctuation that depended on river channel proximity. Although the growth of all species tested was affected in a certain extent by water table fluctuation, *Citharexylum myrianthum* was more strongly affected by it, while the distance between the planted trees was a more important factor influencing the growth of *Schinus terebinthifolius*. Fluctuation of the water table needs to be taken into account when establishing a restoration planting in riparian areas, as well as the type of species that are well adapted and therefore suitable for restoration in such riparian habitats.

012.03 - Facilitation in restored seasonal tropical forest: interaction of canopy attributes and soil water storage capacity.

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Plant-plant ecological interactions are biotic drivers of community assembly. Neighboring plants experiment a trade-off between competition and facilitation, which vary in time and space, and might cause physiological responses in individual species. We aimed at investigating whether the facilitation role of some trees with contrasting canopy traits in restored forests are dependent of soil properties. We evaluated the regenerating community (species richness and density) under individuals of *Ormosia arborea* (Vell.) Harms (slow-growth evergreen, dense foliage) and *Anadenanthera colubrina* (Vell.) Brenan (fast-growth, deciduous, sparse foliage), in restoration systems implanted respectively in a high-fertility, clayey nitosol; and in a lower fertility, lower water storage capacity ultisol. We also evaluated stomatal conductance, water relative content, leaf water potential and vapor pressure deficit in saplings regenerating under each species' canopies. The experimental area is located in the center-south region of Sao Paulo state, Brazil. In the more fertile soil, we observed no differences in regenerating vegetation density and richness under either species, despite their contrasting canopy traits. Nevertheless, in the less fertile (and with lower water availability). *Ormosia arborea* had a clear facilitating role, permitting the regeneration of a denser, richer and not water-stressed understory, while under *Anadenanthera colubrina* trees; several water-stress symptoms in the understory plants were observed. Our results show that the planted species might have different effects on the community assembly in restored tropical forests, depending on the interaction of their functional traits and the abiotic environment. Species choice for tropical seasonal forest must take into account these interactions.

012.04 - Edaphic properties drive the effects of vegetation composition on litter fall and nutrient inputs in tropical seasonal forest restoration systems

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Restoring healthy ecosystem not only involves recovering biodiversity, but also the ecosystem processes and functionality. Among those, nutrient cycling processes have not been sufficiently explored in tropical forest restoration studies. We investigated the influence of vegetation composition and soil properties on nutrient cycling processes. We assessed litter production and nutrient inputs in five different tropical seasonal forest restoration systems (control, i.e. passive restoration; direct seeding, agroforestry system, commercial mixed-species plantation, and high-diversity plantation) at two sites with contrasting soil fertility. We also studied adjacent seasonal semideciduous forest remnants as reference systems. Systems with higher and intermediate species richness had higher litter and nutrient inputs, regardless of site conditions, and did not differ from the forest reference systems. Species richness and the proportion of nitrogen-fixing species significantly affected litter and nutrient inputs, but only in the less fertile soil site. In the more fertile site, stand density explained the higher litter production in the high-diversity and commercial mixed-species plantation systems. Our results suggest that in degraded or low-fertility soils, some particular functional traits, rather than species richness, will affect the success of restoration, regarding nutrient cycling. Nevertheless, the magnitude of species richness and nutrient cycling relationships depends strongly on site abiotic conditions.

012.05 - Influence of topography, soil nutrients and tree diversity on productivity of native timber species

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The increasing deforestation of tropical lands during the last decades has led to forestry management policies aimed at sustainable management of degraded lands. Obtaining economic income from timber sales may encourage landowners to diversify their land uses beyond pastures, and thus promote reforestation.

A clear understanding of nutrient constraints on productivity of native timber tree species, is essential to maximize both the economic return on reforestation and the ecosystem services in tropical degraded lands.

In 2008, a unique and fully replicated design with 267 plots and 21 treatments was set up as part of the AGUA SALUD project in Panama using five native timber species (*Anacardium excelsium*, *Dalbergia retusa*, *Pachira quinata*, *Tabebuia rosea* and *Terminalia amazonia*) planted in both mixtures and monocultures. Here we analyze growth as a function of soil fertility and topography on open grown trees to assess their relative importance in determining aboveground biomass (AGB). Locally derived, species specific allometric biomass regression models were used to determine aboveground biomass (AGB) and relative growth rates (RGR). Soil samples were analyzed for both macro and micronutrients in each plot. Multivariate statistical techniques were used to evaluate different responses of the species to soil fertility and landscape configuration.

Three years after planting *Terminalia amazonia* showed the highest RGR of the species and the highest biomass accumulation, while the lowest RGR and biomass accumulation was exhibited by *Tabebuia rosea*. *Pachira quinata* and *Dalbergia retusa* did not respond to availability of soil nutrients as much as the other target species.

012.06 - Natural processes for the restoration of disturbed sites

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Ecological restoration is defined as the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. This definition suggests that all our efforts, however large they may need to be, are directed to assisting the return of natural processes. In many cases, in fact, natural processes can often be harnessed as a major mechanism of recovery, reducing the degree of input required. The new standards for ecological restoration suggest (Section III, 2.3) that, "All treatments are undertaken in a manner that is responsive to natural processes and fosters and protects potential for natural and assisted recovery." Natural processes have been restoring naturally disturbed sites (volcanos, landslides, glaciation, asteroid impacts, sea level changes, river bank erosion, etc) for millions of years. By understanding how these recovery processes operate to restore these natural disturbances, strategies for the restoration of human caused disturbances can be developed. The first step in defining effective restoration strategies is to identify the filters (constraints) that are preventing the recovery of the ecosystem. Eight abiotic filters such as compaction, steep slopes, and adverse chemical properties and six biotic filters including herbivory, competition and lack of propagule availability are found in sites requiring restoration. By addressing the filters that are preventing recovery without introducing new filters, the natural processes that have been operating for millions of years can assist the recovery of the disturbed site. Examples are drawn from the author's experience.

S13 The Restoration Opportunities Assessment Methodology (ROAM) as a contribution to restoring degraded and deforested landscapes in support of the Bonn Challenge

Organizers: James McBreen & Leander Raes

S13.01 - Introduction to the Restoration Opportunities Assessment Methodology (ROAM) and its implementation

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The potential of forest landscape restoration (FLR), as a nature-based solution to restore ecological integrity of landscapes and deliver multiple benefits for all, is tremendous. With FLR firmly included in domestic and international agendas, the global community is increasingly committed to the restoration of degraded and deforested lands. To date, there are forty pledges (from national and subnational governments, associations, private sector) totalling 148 million hectares as Bonn Challenge commitments. Importantly, implementation of these commitments will not only contribute to achieving domestic objectives such as food production and stabilisation of riverine areas but also to the Aichi Targets, Paris Agreement and the SDGs.

IUCN is employing FLR and using the Restoration Opportunities Assessment Methodology (ROAM) as a means to support decision-making at national and subnational levels. A diversity of thematic areas has been drawn on, and include gender equity, food security, climate smart agricultural production, ecosystem services (mitigation, adaptation, biodiversity, water), finance strategies, and others. In this sense, IUCN is implementing the Bonn Challenge pledges, promoting the FLR approach, and carrying out assessments of restoration potential using ROAM; supporting work on 33 assessments in 23 countries. Much experience has been gained on FLR and ROAM, some of the most significant are: value of natural resources, carbon accounting and degradation measurements, halting habitat loss and fragmentation, reconciling conservation goals with livelihoods, enhancing water quality and quantity, and growing and sustaining livelihoods. Therefore, SER2017 is an excellent opportunity to share some of these experiences and generate an exchange among participants.

S13.02 - Peru's National Programme for the Recovery of Degraded Areas: A Strategy for the rehabilitation of forest landscapes

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Peru covers 1,285,216 km², with 60% of this area in the Amazon Basin, placing it only second to Brazil in terms of tropical forest area. However, deforestation rates exceed 150,000 ha/year, with over 9 million hectares of deforested and degraded land due to overgrazing, agriculture, and other unsustainable land-use practices. 1,285 km²

In this context, in 2014, Peru pledged the restoration of 3.2 million hectares as part of Initiative 20x20, a regional platform in support of the Bonn Challenge – a global effort to bring 150 million hectares of degraded and deforested land into restoration by 2020 and 350 million by 2030. The Ministry of Agriculture and Irrigation (MINAGRI), through the National Forest and Wildlife Service (SERFOR), is leading the process towards the restoration of forest landscapes in Peru, with support from the public and private sector, and National and International Cooperation.

With increased interest in adapting forest landscape restoration (FLR) to their national context, the development of the National Programme for the Recovery of Degraded Areas (PNRAD) was initiated through an articulated and participatory process. The Restoration Opportunities Assessment Methodology (ROAM) guides this decision-making process in Peru, identifying opportunities and strategies to recover degraded ecosystems in an ecologically, economically and socially compatible way, and facilitating high-level political support from MINAGRI and the Ministry of Environment in the FLR process. Implementation of the PNRAD

with a landscape approach, will contribute to integrating multiple objectives, including reducing emissions from deforestation, increasing adaptation, facilitating sustainable rural development and unlocking climate-smart private sector investments.

S13.03 - ROAM in post-conflict Eastern Antioquia, Colombia

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Colombia announced its one million hectare pledge to the Bonn Challenge and as part of the strategy we are applying the ROAM, developed by IUCN and WRI, focuses on the eastern department of Antioquia, in the municipalities of San Carlos, San Luis, San Francisco, Carmén de Viboral and Sonsón that form part of a proposed Puma corridor, an initiative led by the regional environmental authority – CORNARE, a partner in the restoration opportunity assessment alongside the Catholic University of Antioquia. The area has experienced one of the highest deforestation rates in the country and armed conflict, however, it still has enormous potential for the conservation of a high biodiversity and ecosystem services, especially in relation to water quality and quantity. We prioritized the area based on the quality of the forest in terms of shapes, size, land use conflict and drainages. We include a socio-economic analysis based on the cost benefit of the restoration and the productive systems and the livelihoods of the population. We want to bring new opportunities to the return of people displaced by the armed conflict, as well as the reintegration of guerrillas having signed an end to the conflict with the FARC. This presents an opportunity, whereby restoration and other sustainable activities such as ecotourism offer new livelihood options for these populations. The ongoing restoration assessment processes can play a significant role in reducing further degradation and deforestation in Antioquia, and potentially improving the performance-based payments for forest conservation and preservation in Colombia.

S13.04 - Policy processes and ROAM implementation in Brazil – going beyond analytical efforts

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S13.05 - The Assessment of Biodiversity in Forest Landscape Restoration

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Restoring forward to meet current and future challenges is a mantra within Forest Landscape Restoration (FLR). These challenges have real and lasting implications for families and livelihoods and a key component of FLR is ensuring that restoration addresses the drivers of landscape degradation which are almost entirely human-induced. For example, activities that support forest restoration through a landscape approach can enhance gender equity, well-being and livelihoods across degraded landscape. Yet, through addressing the social challenges that stem from degraded landscapes, FLR also importantly addresses biological challenges as well.

Restoration is a key activity to achieve national needs and international commitments, especially to the CBD, UNCCD, UNFCCC, and the SDGs. The Restoration Opportunity Assessment Methodology (ROAM) has proved useful in identifying options for increased connectivity between landscapes, ecosystems and habitats. An integrated approach includes the evaluation of restoration opportunities and cost-benefit analysis of transitions, which allow understanding of social, economic and ecological aspects for planned restoration activities, permitting more effective monitoring over the long term.

The restoration of an ecological trajectory is a foundation of ecological restoration. FLR, while internalizing the ethos of ecological restoration, takes a necessarily more pragmatic approach in degraded areas at the national or subnational scale. Despite this pragmatism, FLR by necessity must include an ecosystem approach based on restoring biodiversity to have any hope of lasting and meaningful landscape restoration. This session will explore the impact that FLR can have on biodiversity and the methods developed for the assessment of biodiversity within FLR processes.

S13.06 - Experiences developing capacity for ROAM using intensive online learning tools

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The Restoration Opportunities Assessment Methodology (ROAM) provides a framework for environmental decision-makers and practitioners to identify, analyze, and prioritize restoration opportunities in order to develop a suite of restoration strategies for particular contexts. From May 2016 to March 2017, the International Union for Conservation of Nature (IUCN) and the Environmental Leadership & Training Initiative at Yale University (ELTI) implemented a series of online courses in four languages for over 120 environmental leaders engaged in Forest Landscape Restoration (FLR) in the tropics. The course was designed to develop the capacity of future leaders to plan and carry out ROAM processes and the restoration of degraded and deforested landscapes within the countries committed to the Bonn Challenge. By situating ROAM within a broader framework of academic knowledge on tropical forest and landscape ecology, relevant socio-political and economic processes, and tree-based restoration strategies, the course aimed to support individuals involved in FLR policy, planning, and implementation to develop the foundation needed to achieve diverse restoration objectives. This presentation will focus on ELTI and IUCN's experience using online training tools for developing capacity for ROAM and FLR, as demonstrated by the recent IUCN-ELTI online courses. We will present the results of follow-up surveys and highlight the experiences of individuals applying what they learned in the course through the planning and implementation of ROAM processes and restoration activities in tropical countries throughout Asia, Africa, and Latin America.

014 Effective communication in restoration ecology

014.01 - Using the nexus between Traditional Knowledge and Western Science to Advance Conservation Biology Globally

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Restoring landscapes and communities involves addressing the needs and concerns of multiple stakeholder groups. When working in a region that includes Indigenous communities, it also means working across the deep cultural divide that often exists between Traditional Ecological Knowledge and Western science. We will present the lessons learned and partnerships developed in restoring bison (*Bison bison*), fire, wolves (*Canis lupus*), and fescue (*Festuca* spp.) grassland habitat in southwest Alberta, Canada by the Kainai (Blackfoot) First Nation, the Kainai Environmental Protection Agency, Waterton Lakes National Park, and Earthwatch Institute, using collaborative, co-created science that balances Traditional Ecological Knowledge and Western Science. This research is part of a transboundary bison reintroduction taking place in the US and Canada. In working toward bison repatriation in this landscape, we have found that partnerships at federal and tribal governmental levels that include non-governmental organizations and universities can deeply engage landowners, tribal elders, citizen-scientist volunteers, students and their teachers, and ecologists. Such collaboration provides a powerful heuristic framework to do ecological research and advance conservation. This model incorporates education, a key element in strengthening relationships and finding solutions to conservation challenges. Elders will provide a Kainai science perspective, creating a legacy when the project is completed that tribal and non-tribal members can refer to and use for future ecological restoration. By incorporating such partnerships, this model feeds back knowledge gained on multiple levels, creating financial benefits, improving ecosystem services, and empowering Indigenous communities in land stewardship.

014.02 - Encouraging SER-endorsed principles of restoration in China

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“Restoration” is a catchall term that is sometimes used for making limited environmental improvements that diminish biodiversity and disregard principles endorsed by SER. Using row-planted tree monocultures to “restore” forests around the world is a prime example. To encourage restoration in China which complements SER’s foundation documents, we are developing formal workshop programs for professional personnel who are employed by natural resource agencies. We co-authored a book in Chinese on the management of restoration projects as a text for these programs. We initiated montane and riparian restoration projects that serve as demonstrations for these programs. One of us (JL) organized two national restoration organizations for natural resource professionals. Both of us have given in-depth instruction in restoration at several universities. We seek other restoration professionals who can collaborate and contribute to these efforts in China.

014.03 - Ecological restoration capacity-building: is it reaching the right audience? An assessment from a Mexican experience

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Capacity building is supposed to be an essential component for improving ecological restoration (ER) outputs in large-scale restoration efforts, but there is little information concerning the factors that should be emphasized when building ecological restoration capacities. In this work, we review a six-year experience on capacity building from a Mexican NGO, Pronatura Veracruz (PV) and Instituto de Ecología (INECOL). Courses are aimed at young researchers, independent consultants, corporate technicians, government specialists, community leaders, and NGO technicians. Courses are web-based and include practical field work,

and focus on project planning and diversified techniques for active restoration. Students must propose a final, practical project, reviewed by other students and a technical committee. Each year, new lecturers are added. So far, 262 students have finished the course (206 TMCF, 56 MF) and there are 107 lecturers from several countries (e.g.: Mexico, USA, Colombia, Belgium, Australia). Realized audience have been mainly composed by young researches (31.3%), government specialists (26.7%), and NGO technicians (18.7%). Independent consultants (4.2%) and community leaders (2.2%) were barely reached. Potential work sites are distributed in 20 Mexican states and in several Ibero-American countries (Colombia, Ecuador, Guatemala, Panama, Spain). Resulting work has reached Mexican national policy and management of national protected areas. The results show that targeting government specialists provides impact on policy. In contrast, community stakeholders and independent consultants should be effectively reached to implement local restoration actions. Ecological restoration courses should be designed for improving profiles of practitioners, providing access to core information about ecological restoration science and practice.

014.04 - Going where science can't go: Inspiring the public in marine restoration through story

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The restoration of a habitat-forming seaweed (crayweed) is currently being scaled up along the entire Sydney coastline, within the marine 'backyard' of Australia's largest city. There is thus a need to raise public awareness and inspire support, but marine restoration suffers from invisibility, hidden below water. Story poses one solution to help the public visualize restoration efforts and benefits. Studies suggest that using narrative to communicate science to non-experts can be effective for acquiring knowledge and persuading attitudes. Few empirical studies however, have examined the effectiveness of narrative to explain science adopting both quantitative and qualitative approaches. We tested the effectiveness of different modes of science communication to increase knowledge about the local marine environment and to improve attitudes towards marine conservation during a popular coastal sculpture exhibition event. Participants (N = 525) were randomly assigned to either a control group or to a science communication treatment that explained the science behind crayweed restoration, either in a factual manner or using a narrative style (film/ podcast with and without music). The narrative style of communication improved the participant's knowledge of the science behind the restoration, but only for information presented during the narrative climax. We also uncovered the interesting findings about the public's knowledge, with many incorrectly identifying corals rather than seaweeds as the dominant habitat-forming organisms in Sydney. This research has implications for how to best communicate science, and also provides a valuable understanding of the public's perceptions of the marine environment.

014.05 - Cooperative Extension: A Model of Science–Practice Integration for Ecosystem Restoration

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Restoration ecology is a science, driven by practical application. Despite the well-recognized disconnect between the science and practice of ecological restoration, there is a lack of practical solutions. In 2014, US agriculture marked the 100th anniversary of the Cooperative Extension Service, providing a timely reminder that the divide between science and practice can be bridged successfully. Major restoration efforts are underway across the globe and integrated science–practice communication is required to avoid project failure and a significant waste of resources. Here, we propose a three-tiered approach, re-emphasizing the integration of science-based practice in restoration utilizing the structure, function, and potential for success of the Cooperative Extension Service of the US Department of Agriculture (USDA) as a model for connecting science and practice in ecosystem restoration.

014.06 - Bogotá Tropicarium, public policy for the biodiversity understanding

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Colombia has the second highest level of biodiversity in the world with over 56,343 registered species, including 30,011 plants of which 7,897 are endemics. Within the framework of public policy for biodiversity, the Bogotá botanical garden manages and directs around \$8 million toward its strategy for ex situ conservation. The focus includes conceptualization, construction, filling and enrichment of the new Tropicarium, which will be the more important greenhouse style structure in South America because its technological style incorporates bio climate principles and sustainable construction and due to the representation of species that it will preserve. Ecosystems are chosen to be represented in the Tropicarium based on their state of alteration and damage risk, which determine the necessity to preserve the main species to ensure their understanding and conservation. As the first step in the building of the Tropicarium, an architect contest was held. Five big rooms represented strategic Colombian ecosystems with the aim to show the genetic patrimony and resulting goods and services that they offered. All of this implies an ambitious architectonic project and a challenge to the Colombian biodiversity. The Tropicarium development will guarantee educative productive processes, the consolidation of the resilience models for the native flora conservation, the generation of information for ecological restoration processes, and a centralized source for research, diversity conservation and education in Colombia.

S15 Is direct seeding the promising restoration method for tropical forest and savanna restoration? Ecological, social and economic outputs from Brazil

Organizer: Daniel Vieira

S15.01 - How was it possible to restore 2000 ha of tropical forest by direct seeding?

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The Xingu river headwaters, in the Brazilian Southeast Amazon, have been progressively deforested. We present how the Campaign Y Ikatu Xingu “Save the good water of Xingu” has put in the same table landowners, researchers, indigenous people, governmental and non-governmental organizations to discuss water conservation, resulting in a great pact for the restoration of riparian forests. These areas are mostly on large agricultural zones lacking natural regeneration, where the greatest challenges were absent nurseries, distances on hardly trafficable roads and high costs associated with manual restoration, especially due to the scarcity of regular workers on highly mechanized farms. In 2006, we tried native seeds in agricultural machines used on these farms for sowing cereals and pastures. Each hectare was prepared as cropland and direct seeded with 200,000 seeds of trees, shrubs, and lianas plus 150,000 seeds of sub-perennial legumes used as green manure. Monitoring of germination, invasive plants, animals and adaptive management is carried on by farmers. Ecological monitoring on permanent parcels showed high sapling’s density (around 1/m²), fast vegetation cover and species recolonization, costing about US\$ 1,845/hectare. Over 2,000 hectares of riparian degraded areas have been direct-seeded with this mix of seeds, known as muvuca, on tens of municipalities and hundreds of farms. The campaign’s demand for seeds was met by 25 communities of indigenous people and peasants organized in the Xingu Seed Network Association, which supplied 175 tons of 165 native species seeds and added US\$ 1,000,000 to the income of 450 forest people since 2006.

S15.02 - First large-scale restoration project of Brazilian savannas

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Grassy biomes are threatened by land conversion and afforestation. In Brazil, boosted by commodities, land conversions go beyond legal requirements, resulting in ~5 million hectares of environmental liability. Currently, restoration mainly involves forest tree planting, but Cerrado flora is 80% savannic. The only large scale Brazilian savanna restoration happened at Chapada dos Veadeiros National Park (CVNP). The challenges are: dominance of African grasses; predominance of vegetative reproduction; and plants slow growth. The research project at CVNP (since 2011) has the aim to develop techniques to replace African grasses by native grasses, forbs, shrubs and trees, by using direct seeding and mechanization to reduce costs and decrease the need for continuous maintenance. Based on these experiments, 94 hectares were direct seeded for restoration in 2015/2016. After five years testing soil preparation techniques, seeding density and composition, our main findings are: (1) soil plowing is key because it helps to control invasive grasses and improves native seed germination; (2) fire before soil preparation helps decreasing grass cover by burning seeds and reducing above-ground grass biomass, improving plowing efficiency on uprooting invasive grasses; (3) we identified at least five native ground cover species with high competitive ability against invasive grasses; (4) 83 native species showed field establishment through direct seeding. These results indicate a possibility to initiate restoration of Cerrado savanna through direct seeding. Furthermore, the cost of direct seeding (~USD 2,500/hectare) is much lower than nursery-grown seedling planting (~USD 7,000/hectare), which usually only uses forest tree species, inadequate to savanna restoration.

S15.03 - Environmental recovery and production from direct seeding in Amazon Portal: lessons from the Sementes do Portal project

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"Sementes do Portal" is a project coordinated by Instituto Ouro Verde and supported with resources from the Amazon Fund / BNDES. It began in 2010 with the main objective of supporting the recovery of permanent protected areas and the diversification of production using agroforestry systems with direct seeding technique, involving family farmers in northern Mato Grosso, Brazil. There are about 1,100 small properties which have implemented these techniques, with different levels of success, resulting in more than 2,200 hectares of agroforestry. The project focused on creating a network of services that are considered essential to facilitate farmers' access to agroforestry. Each agroforestry was planned based on the farmer's objectives, his work capacity and the environmental conditions. In all areas there were 20 to 80 agronomic and forest species that were used with the simultaneous planting of short, medium and long life species. Amongst the main lessons learned from this experience are: (i) the importance of community articulation and participatory management to ensure scale and farmer's engagement; (ii) the requirement to organize a network of seed collectors; (iii) the importance of training activities to ensure the quality of seeds, planting and management of the areas; (iv) the creation of new commercialization channels to agroforestry products and (v) the importance of an individualized assistance to the farmers, mainly in the case of agroforestry created for economic purposes. In terms of agroforestry development, the biggest challenge is to maintain the biodiversity and the economic benefits from the initial agronomic cycle throughout the forestry and fruit cycle.

S15.04 - Challenges for scaling-up native seed production to direct seeding in the Brazilian dry areas: A seed technology approach

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Direct seeding contributes to promote ecological restoration, and add diversity into early-successional stages as well. However, seed supply is a bottleneck for forest restoration. Our objective is to present a critical analysis of the production and the accumulated knowledge on seed technology, production and research of native forest species for direct sowing in dry areas. In Brazil, to supply the demand for governmental commitment along the next five years, it is necessary a production of about 60 tons/year, but there is an estimated installed infrastructure of 29 ton. Despite the potential demand for restoration, legal requirements bring instabilities and uncertainties to seed trading. These restrictions may have made illegal part of the small producers and seed harvesters, who account for about 60% of the seed supply chain. Seed production is used for seedling production and private nurseries usually produce seeds by themselves or buy them from seed harvesters. Private and legalized nurseries are relevant; however, they are unable to supply the demand neither on species richness nor genetic quality. Seed research is concentrated on few early successional species, most of them easy to produce. Few pioneer species dominated restoration and direct seeding and small seeds require increasing field emergency. Many seeds of late successional species are either recalcitrant or show complex dormancy that reduce its potential use in direct seeding, demanding technologies to increase seed drought resistance. Priming and pelleting are technologies essentials for seed emergency in dry areas, but up to now neglected for forest species.

S15.05 - Understanding the ecological outputs of direct seeding restoration

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Direct seeding is an emerging strategy for forest and savanna restoration. We reviewed the ecological outputs of direct seeding for forests and savannas, based on the results of two large-scale projects in Brazil. For forest restoration, direct seeding follows the principles of secondary succession, including shrub and tree species with life cycles varying from 3 months to long-lived trees. High seeding density results in high density of poles and in the establishment of seedlings and saplings of late successional tree species in 7-10 y old restored forests. These forests are similar to resilient early secondary forests, except for its lower species richness, which could be increased by combining direct seeding with high diversity seedling planting in low density. For savanna restoration, direct seeding follows the priority effect hypothesis; the effectiveness of restoration depends on the fast establishment of an herbaceous layer that can cover the soil and prevent exotic grasses re-colonization. Whereas slow-growing trees establish but do not dominate recently restored areas. Native grass, herb and shrub species can rapidly establish and spread in restoration sites, but exotic grasses are still present. Many tree species have high field establishment. Direct seeding may be a mainstream method for forest and savanna restoration, but technological improvements are needed especially to (i) enhance soil preparation techniques to increase native species germination and control exotic grasses before seeding, (ii) improve seeding techniques, and (iii) increase the diversity of restored areas.

S16 The use of biocrusts for restoration and rehabilitation in drylands: limitations, advances, and new perspectives

Organizer: Sonia Chamizo

S16.01 - Rehabilitation of arid soils by inoculating exopolysaccharide-producing cyanobacteria: The role of the extracellular polysaccharidic matrix in the improvement of soil quality

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In the last decades, a constant increase in the extension of lands degraded owing to the conversion of natural areas to farmlands or urban areas and to the impacts of climate change was observed. In order to mitigate these on-going degradation processes in drylands and to restore the degraded soils, large scale and low-cost sustainable biotechnological approaches are urgently required.

In arid and semiarid environments, soil carbon sequestration (CO₂ fixation) by cyanobacteria and by Biological Soil Crusts (BSC) is considered an eco-friendly and natural process to increase soil C content and a viable pathway to contrast desertification and to favor soil rehabilitation. Within this context, inoculation-based techniques with exopolysaccharide producing cyanobacteria have proved to be a viable and sustainable pathway to increase soil biomass, soil stabilization and soil fertility. In this presentation a particular focus will be given on the role of the extracellular polysaccharidic matrix (EPM) synthesized by cyanobacteria in giving the structure to induced BSCs and to enhance their water trapping and retaining capability. The EPM was extracted separately removing the tightly bound exopolysaccharidic fraction (TB-EPS) and the loosely bound exopolysaccharidic fraction (LB-EPS) from BSCs. Significant differences in the monosaccharidic composition and in the molecular weight distribution of the two fractions suggests distinct roles of TB-EPS and LB-EPS fractions within the crust system. Indeed, TB-EPS most likely affects BSC structure and water-retaining properties, while LB-EPS most likely contributes to the intake of C in the soil, thus favoring the growth of the chemoheterotrophic microbial community.

S16.02 - Inducing biocrust development by cyanobacteria inoculation to restore dryland ecosystems

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Climate change and anthropogenic activities including intensive farming of agricultural land, overgrazing and conversion of natural areas to farmlands and urban areas are leading to accelerated degradation processes in terrestrial ecosystems all over the world. Land degradation is particularly dramatic in drylands, which cover about 40% of Earth's land surface and support over 1 billion people. In these regions, low vegetation cover, water scarcity and soils characterized by poor structure and low fertility make challenging the successful implementation of restoration measures to combat degradation processes. Inoculation of soils with cyanobacteria in order to promote artificially induced biocrusts is presented as an innovative and viable alternative to restore damaged soils due to their ability to fix atmospheric C and N, and synthesize exopolysaccharides which increase water retention and soil stabilization, thus reducing soil erosion. The main goal of this study is to analyze the feasibility of different (N-fixer and non N-fixer) cyanobacteria strains to promote biocrust development on different textured soils, as well as monitor the changes in soil properties during biocrust development. The effect of cyanobacteria inoculation on exopolysaccharide and organic carbon content, chlorophyll a, aggregate stability, hydrophobicity, roughness and surface reflectance were examined in the soil types under laboratory conditions. In addition, the effects of different cyanobacteria strains on soil properties were examined at plot scale under field conditions. Our results point to the viability of using cyanobacteria, inoculated individually or as a consortium, as a successful strategy to improve soil quality during the early stages of soil restoration.

S16.03 - Assessing the effects of native-cyanobacteria inoculation: New insights for the restoration of drylands degraded soils.

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In drylands, the stochastic nature of rainfall and rapid loss of moisture availability, along with the high thermal and ultraviolet stresses, generate limiting conditions for plant reestablishment and growth. On the contrary, biocrusts can adapt themselves to these extreme environmental conditions and play important functional roles in arid ecosystems. Within biocrusts, cyanobacterial crusts are especially resistant to harsh environments and may be cultivated ex-situ to rapidly generate enough biomass to restore soils at large scales. Therefore, artificial cultivation and inoculation of cyanobacteria is arising as an attractive soil bioremediation technique. With the aim of knowing the aptitude of cyanobacteria-inoculation strategy to restore soils, three different degraded arid soils from Southeast Spain were inoculated with representative native cyanobacteria at laboratory and field conditions and their effects on soil properties were evaluated. Different treatments were assessed such as the inoculation of strains individually vs a mixture of species, watering treatments or the addition of compounds. We found a gradual increase in biocrust cover and development, significant changes in the surface spectral response and higher net CO₂ fixation and SOC content in the inoculated soils compared to the non-inoculated. The inoculation of *Nostoc* individually and the consortium of three strains promoted the highest soil properties improvements. Watering had a lower effect than expected while the addition of some compounds had surprising effects. Preliminary and short-term results from the inoculations on field plots are presented. Our results demonstrate that soil cyanobacteria inoculation constitutes a promising alternative for dryland rehabilitation.

S16.04 - Strategies for growing and establishing moss for biocrust rehabilitation

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Syntrichia is a globally distributed biocrust moss genus that is a common component of dryland soil communities. Various working groups have demonstrated the ability to cultivate *Syntrichia* spp. in growth chambers, greenhouses, and field settings, with the goal of producing biomass in quantities and at rates relevant to applied biocrust rehabilitation. We discuss our attempts to maximize *Syntrichia* spp. growth in a greenhouse, identify potential sources of stress while under cultivation, and discuss outcomes from field establishment trials. We found that different populations within *Syntrichia ruralis* differed in rates of growth and in their ability to tolerate stress. These populations also differed in the composition of microbial associates, which developed voluntarily during cultivation. This suggests that source provenance of *S. ruralis* may prove important when deploying to rehabilitation sites. Early cultivation trials indicated that *S. ruralis* is more difficult to grow than other biocrust mosses, but there may be a modest degree of facilitation if multiple species are grown together. Later trials employing microclimate manipulations within the greenhouse environment revealed that shade cloth improves growth and reduces stress. In field establishment trials, we found that hardening treatments to prepare greenhouse grown tissues for outdoor establishment were not important, but application of jute cloth does improve establishment. We discuss our efforts to adapt existing restoration technologies, seed drilling and imprinting, for the purpose of meso-scale dispersal of moss propagules. Future directions of our research include development of new cultivation systems and expanding to agronomic scale production of biocrust mosses.

S16.05 - Microbial biobanking: maximising the returns from topsoil to facilitate mine site rehabilitation

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Mining rehabilitation requires key solutions to complex issues relating to ecosystem function. In arid landscapes, the removal or disturbance of topsoil incorporating biocrusts can result in a shift in ecosystem function. Biocrusts regulate soil moisture, sequester carbon and fix significant quantities of atmospheric nitrogen. Cyanobacteria, as ecosystem engineers, initiate biocrust establishment and facilitate soil surface stabilisation. Exopolymeric secretions (EPS) by cyanobacteria form cohesive and

protective layers at the soil surface, minimising wind erosion. In newly developing biocrusts EPS forms organic bridges tightly binding soil aggregates and particles. This research encompassed soil microbial community profiling (using a polyphasic approach) with a focus on 'biobanking' topsoil for rehabilitation purposes. The research was in collaboration with Iluka Resources at Jacinth-Ambrosia (J-A) mineral sand mine located in a semi-arid chenopod shrubland in southern Australia. At J-A diverse biocrusts included a significant representation of cyanobacteria, lichens and mosses that inhabited nearly half the soil surfaces. Following stockpiling, cyanobacterial taxa recovered at different rates. In simulated rehabilitation trials, cyanobacterial growth was seasonal, impacted by moisture availability, environmental stress and disturbance. Seasonal timing for the return of topsoil impacted biocrust reestablishment and inoculation needs to reflect their natural growth cycles. Facilitated rehabilitation through the inoculation of cyanobacteria at the time of rehabilitation may be an effective means to boost biocrust establishment and aggregate stability in the early stages. In growth trials biocrust re-establishment with inoculation provided timely soil stabilisation and demonstrated accelerated recovery. Monitoring of biocrust recovery was an effective means of measuring key soil function indicators.

S17 Governance, restoration, and degradation neutrality.

Session 2: how SIACRE countries are progressing?

Organizer: Gustavo Zuleta

S17.01 - Integrating restoration to degradation neutrality: The case of Latin America and the Caribe

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At the global scale, Latin America is probably a unique case of fast networking, institutional strengthening and participatory governance development on ecological restoration (ER), despite degradation rates are still high. The region also harbours the world's second largest community of practitioners and scientists. Brazil is the pioneer country where the first society was founded in 1996. During 2007-2010 the Cuba's Group of Restoration promoted ER at the regional scale. In 2013, Colombia led the creation of SIACRE, the Ibero-American and Caribbean Society for ER. In 2011, the 4th world conference was held in Mexico whereas Brazil is organizing the 7th one in 2017. Last July 2016, Argentina hosted the Regional Workshop of the Land Degradation Neutrality (LDN), a worldwide program conducted by UNCCD. Representatives from 16 countries of Latin America and the Caribbean discussed the conceptual framework, methods to estimate land use/land cover changes (gains/losses indicators), legal and multi-sectorial commitments (national targets), leverage opportunities, and monitoring tools. The LDN main objective is to achieve, by 2030, a land-degradation-neutral world by means of land-soil restoration and sustainable practices of degraded sites. The scope is beyond arid and drylands: it includes all terrestrial ecosystems. Therefore, LDN progress in SIACRE countries since 2016 is relevant (23 countries endorsed the program) and directly connected to the global interests to restore nature for environmental and human benefits. The aims of this symposium are to summarize progresses and to find integration ways to maximize efforts from different initiatives occurring in the SIACRE counties.

S17.02 - Drivers, governance, degradation neutrality and ecological restoration in Chile

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The LDN concept was developed to encourage implementation of an optimal mix of measures political, scientific and social designed to avoid, reduce and/or reverse land degradation in order to achieve a state of no net loss of healthy and productive land. LDN aims to balance anticipated losses in land-based natural capital and associated ecosystem functions and services with measures that produce alternative gains through approaches such as land restoration. LDN target setting is linked to a variety of regional sustainable land management, land restoration and rehabilitation initiatives. In this context, considering the affected areas in Chile by recent fires and new fire patterns occurred during the summer of 2017, being today the main degradation driver, it rises a challenge in the design of special measures that may be implemented in the form of action plans and/or policies at the (sub) national level or in the form of projects that are tailored to specific ecological and socioeconomic challenges at given geographical scale. Additionally, we need to move forward into a political/social environment that allows the incorporation of the LDN concept and actions, also new investment opportunities to finance key measures to achieve LDN. It is relevant to understand that the capacity of regrowth of native Chilean forest species is not an unknown subject for specialists, only from this concept is clearer when to restore and how much to restore, are questions that can be answered once the ecosystem responds, which we estimate will not occur before the next growth period.

S17.03 - Governance, restoration, and degradation neutrality: Drivers, governance, degradation neutrality and ecological restoration in the Caribbean region with an emphasis on Dominican Republic

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The most affected countries by land degradation in the Caribbean are Cuba, the Dominican Republic (DR) and Haiti; In Cuba, it is estimated that 56% of the soils are being affected by degradation processes, in the DR 70% and in Haiti it exceeds 90%. Although this phenomenon has the same causes, the social and economic impacts have different levels. In the DR, the conversion of forests to cropland, as a consequence of increased food demand, represents 55% of the causes of land degradation, which leads to other direct degradation processes associated with inadequate soil management. Since 1980s, there are identified many efforts to reach natural resources conservation, that in one way or another are to prevent desertification and drought in the country. By joining the UNCCD (1996), the DR committed itself to addressing degradation, implemented through the NAP-LCD and implemented through the implementation of policies and structures for democratic environmental governance in line with the commitments made under Principle 10 The Rio Declaration 92. The problem has not been tackled in a comprehensive way, and the new challenge assumed since the COP12, to establish the national LDN goals by 2030, involving all sectors and initiatives related to land use. In this sense, several initiatives are implemented in the country for boosting the recovery process of ecosystems damaged by deforestation, fires, mined areas and other anthropogenic causes. In this way several actions of ecological restoration are being carried out, some with positive results demonstrable through scientific research.

S17.04 - Governance, restoration, and degradation neutrality in Colombia

CAROLINA MURCIA; MANUEL R. GUARIGUATA

Colombia has a 50+ year history in implementing ecological restoration projects (ER). Until 2012, the government led or else implemented a large proportion of these projects, as part of national policy, and mostly on public lands. In contrast, NGOs and Universities had implemented less than half ER projects and with minimal local participation. These trends, however, are likely to change in the near future due to several factors. Although a National Restoration Plan is in place, available area of public land is limited. Since State agencies cannot implement restoration on private lands, a new mechanism needs to emerge to ensure that Colombia's goal of restoring one million hectares is fulfilled by 2035. Furthermore, Colombia's biodiversity offset policy is based on the no-net-loss principle (i.e., "land degradation neutrality") and requires that environmental compensation be achieved through conservation or restoration. Hence, the private sector is gradually engaging in ecological restoration either directly or through consultancies. Due to land scarcity, contractual agreements with private land owners are being established to meet specific land quotas imposed by the biodiversity offset policy. While local landowner engagement in ER is increasing, that is mostly determined by external initiatives that seek to engage local actors; therefore their role is still unapparent. Furthermore, in spite of important advances in regulatory frameworks, loopholes and technical weaknesses are preventing effective ER design and implementation. Thus, Colombia still requires significant adjustments to achieve some degree of land degradation neutrality starting with a significant paradigm shift involving different sectors of society.

S17.05 - The contribution of Initiative 20x20, a country-led platform to the restoration field in Latin America

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Initiative 20x20 is a country-led effort to bring under a restoration process 20 million hectares of degraded land in Latin America and the Caribbean (LAC) by 2020. Today, Initiative 20x20 has 49.7 million hectares of restoration pledges from 14 countries, and three regional programs. The objective of the Initiative is to change the dynamics of the land degradation process in LAC. The initiative has three main activities: a) a political dialogue to strengthen policies and address barriers faced by land restoration in the region; b) a technical effort in support of national restoration goals and c) an effort to bring private investment into restoration to complement scarce public resources. Restoration strategies have been defined by the participating nations and include landscape management systems (agroforestry/silvopasture), natural and assisted reforestation and low carbon sustainable agriculture. The initiative also focuses in avoiding degradation. The presentation will focus on the contributions the initiative has already made in the restoration field with an emphasis on the associated private sector investment and the analytical efforts.

It will also provide a summary of lessons learned so far and outline plans for the immediate future. Keywords: Landscape restoration, reforestation, avoided degradation, agroforestry, sylvo-pasture, carbon sinks, economics, finance, governance, degraded land.

S18 Restoring productive landscapes using landscape approaches: Promoting agroforestry and agroecology while improving livelihoods of smallholder farmers in Central America, Brazil and East Africa

Organizer: Leida Mercado

S18.01 - Moving towards an integrated approach to food security, ecosystem services, and climate change: Advancing the Climate-Smart Territories (CST) approach in two Central American rural areas

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A wide range of complex issues affects Mesoamerica, including poverty, inequality, food insecurity, and degradation of ecosystems. The region's social and natural systems are also highly vulnerable to the impacts of climate variability and change. Since 2013, CATIE through the Mesoamerican Agroenvironmental Program (MAP), funded by Norway, and in association with near 60 partners, is simultaneously addressing these issues in two Central American territories: Trifinio (the upper watershed of the Lempa River that is shared between Guatemala, El Salvador, and Honduras) and NicaCentral (the North-Central area of Nicaragua). To tackle these issues, MAP proposes to work at the territorial level with the Climate Smart Territories (CST) approach in order to promote a multisectoral, integrated, systemic bottom-up methodology while ensuring that local needs are taken into account, and providing local actors with the required skills and tools needed to formulate and implement sustainable development solutions. Responses are formulated and implemented at different geographical scales and address restoration of key ecosystems. In 2013, a baseline study was conducted and 12 outcome indicators were estimated. Three additional studies (2015, 2016, and 2017) followed. It is possible to show progress in most of the indicators. For example, six cross-sectoral platforms have strengthened their capacity to better understand and coordinate actions targeted to address issues related to the Sustainable Development Goals (SDG), including degradation of land, water, and forests. At the same time, thousands of households have improved their livelihoods and diets through the use of climate smart farming practices and adopting healthier eating habits.

S18.02 - Guiding Agroforestry-based restoration in Brazil: lessons from application of PLANTSAFS - Planning and Appraisal for Decision-Making on Agroforestry Systems

ANDREW MICCOLIS

Agroforestry—the integration of trees in agriculture and agricultural landscapes—has gained renewed recognition for its potential to contribute to restoration and maintenance of landscape functions and services while also strengthening livelihoods. However, a number of knowledge gaps persist around the optimal (locally adapted) intervention or combination of interventions to integrate trees and enhance tree management across productive landscapes. In order to help fill these gaps and guide restoration-oriented agroforestry initiatives, ICRAF Brazil and partners have developed a socio-environmental appraisal tool (Planning and Appraisal for Decision-Making on Agroforestry Systems - PLANTSAFS) that provides inputs for decision-making by farmers and development agencies at the plot, farm and wider landscape level. PLANTSAFS is based on a set of 30 indicators scored through a dialogue between land owners and technicians or researchers. It sheds light on farmer objectives and evaluates their access to assets (human, social/political, financial, physical, natural) as well as ecological resilience, suitability and sustainability of the agroforestry systems and management practices adopted. Application of PLANTSAFS in two different landscapes in the Amazon and Cerrado biomes in Brazil, and work in progress in the Atlantic Rainforest, have provided key insights on agroecological adjustments needed at the plot and farm level as well as recommendations for farmer groups and development agencies on factors for upscaling agroforestry-based restoration in those landscapes. These insights have fed into decision-making processes regarding systems, species selection, and management practices that can reconcile farmer objectives with ecological functions given the constraints and potentials of each context.

S18.03 - Climate-smart agriculture practices and their contribution to landscape restoration and the well-being of agricultural families

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Innovations in farming systems are needed for the restoration of landscapes whilst improving the wellbeing of agricultural families. We aim to show how climate-smart agriculture practices (CSA practices: those contributing to productivity, adaptation and mitigation of climate change) can help to achieve such goals. We have worked in two Central American territories which are vulnerable to the loss of natural resources and to climate change. Among the dozens of agricultural practices identified in these territories, we characterized, and evaluated the productive and economic performance of 27 CSA practices. Such practices have been promoted and applied in homegardens, basic grains, agroforestry systems and pastures in at least 2500 farms in each territory. We found that CSA practices aim to increase agrobiodiversity and reduce the dependence of external inputs, and are capable to provide several ecosystem services simultaneously; furthermore, CSA practices perform better than traditional practices productively and economically. The provisioning service (grains, vegetables, fruits, milk, meat, timber) is the one which provides nutritive food and incomes/savings for farmers' families. Most CSA practices increase the abundance of plants and trees, considered as proxy indicator of the restoration of landscapes: increasing the herbaceous and tree cover, in thousands of land uses well distributed in a landscape, increase biodiversity and provide regulating and supporting services which are essential for restoration. Therefore, CSA practices have the potential to help restoring landscapes and improve the wellbeing of agricultural families. How policies could help to better promote and invest massively in CSA practices must be explored.

S18.04 - Knowledge-sharing for landscape restoration in the Atlantic Forest of Brazil

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The Atlantic Forest Restoration Pact (PACT) is one of the most innovative and ambitious large-scale restoration programs in the World. Despite the experience and expertise acquired during the last 30 years through the implementation of several projects and research programs, the goal set by the 270+ members to restore 15 million hectares of degraded lands and forests by 2050 is a huge undertaking. To learn from other large-scale restoration initiatives, in 2014, fifteen Brazilian restoration leaders from the PACT and other initiatives visited restoration and reforestation initiatives implemented in China over the last three decades that led to the expansion of forest cover by several million hectares. One of the findings was that China accomplished its large-scale restoration primarily through the establishment of monoculture plantations, which are less resilient and can be limited in terms of the production of ecosystem services and goods. The Brazilian experts were inspired and convinced that large-scale restoration can also be achieved in Brazil. However, issues were raised in terms of the long-term sustainability and benefits from Chinese large-scale restoration programs. In 2015, to demonstrate the higher benefits from using higher plant diversity in restoration initiatives 19 experts from China, Indonesia, and Guatemala visited the Atlantic Forest of Brazil to exchange experiences and learn how forest restoration can support a green economy and healthy society. The learning exchange was successful and several opportunities for future collaboration were identified in the areas of watershed restoration, natural infrastructure, agroforestry systems, restoration economy, and soil microbiology.

S18.05 - Forest and ecosystem service recovery through secondary succession: Lessons from contrasting tropical agricultural landscapes in Costa Rica

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Secondary forest succession should contribute to restoration of productive landscapes (RPL). However, there is little understanding of how and why community characteristics of secondary forests, and their ecosystem services, vary over landscapes. This understanding is vital for evidence-based RPL and must go beyond the traditional focus on how forests change over time. I highlight key aspects of succession for RPL using results of long-term research (1987-present) in two Costa Rican landscapes. An extensively deforested landscape in seasonally dry lowlands has forest on abandoned pastures, strongly dominated by tree

species adapted to cattle ranching environments. Floristically distinct forests with differing functional characteristics – though conservative weighted mean trait values (CWMt) predominate - are associated with soil variation and pre-abandonment pasture management, but not forest age. Species diversity responds to precipitation and spatial factors, suggesting dispersal limitation. On a landscape with ca. 50% remnant evergreen primary forest, succession rapidly establishes forest cover of primary forest species. Species composition, species diversity and woody biomass are affected by soil variation across the landscape and species diversity also by spatial factors. Long-term data show these successions are punctuated by periods of decline of dominant species, which may bring long-term loss of canopy cover and ecosystem services. Science and practice for RPL in the anthropocene must focus on new, socioecologically and climatically possible forest ecosystems and the services they can provide. Monitoring must determine whether succession is meeting restoration objectives, and appropriate silvicultural measures are necessary if it is not.

S19 Deciphering the land: using landscape attributes to estimate the potential for natural regeneration of tropical forests

Organizers: Pedro H.S. Brancalion & Ricardo Gomes César

S19.01 - Natural regeneration to leverage large-scale tropical forest restoration: state of the art and research gaps

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Leveraging the capacity for natural regeneration is a key approach for achieving forest restoration at large scales within the context of forest landscape restoration. Harnessing the potential for spontaneous and assisted natural regeneration can greatly reduce the costs of large-scale restoration while offering multiple benefits to diverse stakeholder groups. We have gathered much knowledge regarding how tropical forests regenerate and how successional changes in biomass and species composition are affected by rainfall and other environmental factors. But many challenges and knowledge gaps stand in the way of implementing natural regeneration at large scales. Spatial studies of natural regeneration and its structure and composition provide an essential foundation for predictive models of the biophysical and social factors that enable successful natural regeneration. Advances are needed to predict the structure and composition of natural regeneration, how to enhance its economic value for landowners and communities, rates of provision of different types of ecosystem services, and importance for biodiversity conservation. We need to understand better the levels and types of environmental degradation and landscape configurations that permit successful forest regeneration or assisted natural regeneration. We lack a clear understanding of the legal frameworks and regulatory structures that will best enable natural regeneration in different regions and make it an economically competitive land use. Additional challenges are to develop educational, social, and cultural programs to help transform farmers, ranchers, families, and communities into stewards, observers, and managers of diverse and dynamic regenerating forests.

S19.02 - Complex socio-ecological drivers of natural regeneration in the Brazilian Atlantic Forest Hotspot

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Understanding the synergies and trade-offs between socio-economic development and natural regeneration are among the major global scientific and policy debates of the last decades. The ecological/biophysical and socio-economic driving forces of natural regeneration and their complex interaction remain unclear, yet such knowledge is urgently needed to identify areas with potential for secondary forest recovery. Here we identify the ecological/biophysical and socio-economic drivers of natural regeneration in the Brazilian Atlantic Forest Hotspot and the synergies and trade-offs between these drivers. To do so, our approach involved four main steps: (1) identify the main ecological/biophysical drivers of natural forest regeneration; (2) predict the potential for natural regeneration across the entire Atlantic Forest based on these ecological/biophysical drivers; (3) identify the main socio-economic drivers of natural regeneration; and (4) investigate the synergies and trade-offs between the ecological/biophysical and the socio-economic drivers of natural regeneration in the Atlantic Forest. The mean overall classification accuracy for the predictive ecological/biophysical model was 95.4%. The main drivers of natural regeneration are: distance to fragments, elevation, bulk-density, sand fraction in soil, and precipitation seasonality (ecological/biophysical), and opportunity cost and rural-urban migration (socio-economic). The increase in the amount of natural forest regeneration (and the potential for that) depends explicitly on economic growth and urbanization. In the Atlantic Forest, natural regeneration is part of a complex process related with landscape, soil and climatic factors and rural-urban transition. This makes natural regeneration an opportunity for new policies of poverty alleviation and reduction of urban-rural inequality by creating jobs and new incomes.

S19.03 - Local and landscape factors influencing structure and diversity of second-growth forests in human-modified landscapes

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Encouraging and protecting natural regeneration are important strategies to achieve international forest restoration goals. An increase in native forest cover has been observed and celebrated by practitioners in several regions, but little discussion focuses on the quality of these forests and few studies have examined the influence of landscape and local factors on features of second-growth forests. Our study in the “interior” sub-region of the Atlantic Forest, Southeast Brazil identified the relative importance of local (previous land use, soil fertility and forest age) and landscape (distance from remnant edge, remnant size and nearby human land use) factors on tree community aboveground biomass (AGB), tree abundance, rarefied species richness (RSR) and proportion of pioneers (PP) in second-growth forests. Our results show that structure-related attributes are primarily influenced by local factors and secondarily by landscape factors, while RSR and PP show the opposite trend. Abandoned silvicultural plantings showed increased overall AGB but reduced AGB of native species. Older forests showed higher native AGB, while surrounding intensive agriculture reduced native AGB and number of emergent (DBH>20 cm) native trees. Sapling abundance and RSR increased farther from remnant edges, while PP was reduced in older forests and farther from remnant edges. Local factors can be more easily managed by practitioners to promote forest structure and, thus, ecosystem services such as soil protection and carbon sequestration. A broader, integrated landscape approach would be required to seize the full potential of second-growth forests to develop structure and conserve biodiversity in agricultural landscapes.

S19.04 - The role of exotic Eucalyptus for promoting cost-effective regeneration of tropical forests

PEDRO HENRIQUE SANTIN BRANCALION; RICARDO GOMES CÉSAR; VANESSA DE SOUZA MORENO; GABRIEL COLLETTA; NINO

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The pressing need to restore tropical forests at large spatial scale presents a challenge to develop restoration models that provide income to farmers while also providing multiple environmental benefits. Despite the impression that conservation and restoration are incompatible with commercial forestry, approaches exist that permit synergies between economic benefits and favorable restoration outcomes for biodiversity and ecosystem services. Here we present a case study from Atlantic Forest of Brazil to illustrate how Eucalyptus trees in harvested plantations and in mixed plantations promote the natural regeneration of native forest vegetation and support high levels of biological diversity. We assessed natural regeneration, aboveground biomass accumulation and potential Eucalyptus timber production in 5-year-old mixed plantations of Eucalyptus and native species, and plantations implemented exclusively with native species, in experimental plantings in the states of Espírito Santo and Bahia, and in second-growth forests established in abandoned Eucalyptus plantations and in pasturelands in the state of São Paulo. Overall, mixed plantations with Eucalyptus showed as high species diversity and abundance of naturally regenerating individuals as plantations with only native species, but total aboveground biomass was much higher when Eucalyptus was used. Surprisingly, species richness and proportion of animal-dispersed tree species were higher in second-growth forests established in abandoned Eucalyptus plantations compared to those established in pastures. The exploitation of Eucalyptus timber could potentially offset the costs with restoration implementation. Therefore, Eucalyptus had neutral or positive effects on natural regeneration of native plants, and could be effectively used to promote cost-effective regeneration of tropical forests.

S19.05 - Using landscape attributes to increase restoration cost-efficiency

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There is a need to optimize financial resources in order to enable successful large scale restoration projects. Here we used a previously developed spatially explicit model of natural regeneration potential to address restoration methods, strategies and their respective costs, later comparing different restoration strategies as to restoration costs and ecosystem services provision

in the Brazilian Atlantic Forest. Three landscape units (LU) of 40,000 ha each, located in the Piracicaba river basin in southeastern Brazil were selected for this analysis. Each LU represents a different agricultural landscape, where LU1 is Mechanized Agriculture, with predominance of sugarcane plantations (51%), low forest cover (10%) and lowest slopes (10.2%); LU2 is Pasture land, with predominance of pasture (46%), higher forest cover (20%) and medium slopes (17.8%); LU3 is Forest landscape, predominantly covered by pasture (48%) with highest forest cover (31%) as well as slopes (25.9%). Natural regeneration probabilities were converted to restoration methods and costs. We later applied three restoration strategies to our landscapes (Riparian - RIP, Random - RDM and Cost-Reduction - CST), with the objective of comparing costs. At last, we calculated ecosystem services in relation to the different strategies, comparing costs. Results show that restoration costs can be decreased up to 60% when comparing CST approach to RDM and 30% when comparing CST to RIP. Although total amounts of environmental services were different in each strategy, costs to decrease runoff by 1%, increase carbon stock by 1 ton and increase connectivity by 1% were altogether lower when applying our CST.

S19.06 - Governing natural forest regeneration: Status and trends and views forward

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Environmental governance, defined as the ways and institutions through which individuals and groups express their interests, exercise the rights and obligations, and mediate their differences, is usually composed of a dynamic mix: the state plays a fundamental role yet lack of capacity of many governments to enforce laws and implement regulations paves the way for non-state-based approaches. Finding the right combination of these two is essential for environmental outcomes to benefit both the environment and society as a whole. New international initiatives aimed at increasing restored forest cover by millions of hectares offer the opportunity to reverse the trajectory of forest degradation and loss by investing in forest restoration at a global scale. One cost-effective way is by relying on natural forest regeneration. The extent to which natural forest regeneration is firmly inserted into national or sub-national policy and the way this forest type is governed across tropical countries will undoubtedly influence large scale the success of restoration initiatives. Yet compared to planted forests, natural regeneration suffers from major institutional and policy gaps from the bottom up and top down. Addressing these can help to ensure the permanence of naturally regenerated forests in time and space. Case studies from different countries will illuminate commonalities and differences.

020 Restoration of wetlands

020.01 - Restoring wetland services in agroecosystems to reduce impacts on water quality

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Agricultural land development and intensification generally results in loss of natural wetlands and the ecosystem services they provide, but the tide is beginning to turn. Wetlands are now being recognised as potential tools to help attenuate diffuse contaminant losses in agricultural watersheds. Results will be presented from a single watershed and a multi-watershed regional scale investigation of constructed wetlands for control of diffuse agricultural pollution loads in pastoral agricultural areas in the far south of New Zealand. The aim was to predict the expected reductions in annual nutrient loads resulting from implementation of wetlands for both current dairying extent and potential full conversion to dairying. CLUES modelling predicted that for the six main river watersheds in the study area, constructing wetlands occupying 1% of first order stream catchments would reduce TN loads from dairying land by 5.2% for both current and potential full dairying; TP load by 9.9% for both current and potential full dairying; and TSS load by 21.3% for current dairying and 15.7% for potential full dairying. If wetland areas were increased to 2.5% of the amenable area of first order watersheds overall TN load reductions were estimated to increase to 9.9% for both current and potential full dairying; and overall TP load reductions would increase to 16.8% for current and 16.3% for potential full dairying. These represent the predicted average annual cumulative mitigation rates for many wetlands over large spatial extents. Challenges involved in retro-fitting constructed wetlands back into highly modified agricultural drainage networks are also discussed.

020.02 - Improving management and restoration of submerged aquatic vegetation in wetlands using a state-and-transition model

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Submerged aquatic vegetation (SAV) plays a significant role in the dynamics of aquatic ecosystems, contributing to water quality and providing nutrition and habitat for fish and wildlife. The modified nature of many aquatic systems globally requires that they undergo active management to maintain productive SAV ecosystems, but our understanding of the SAV communities is poor compared to emergent plants. Here, we develop a conceptual state-and-transition model that incorporates empirical field-based data for SAV in semi-permanently flooded wetlands and shallow lakes. We collected information on SAV composition, abundance, and associated abiotic conditions in 52 wetlands in the northern Intermountain West and western Prairie Pothole regions of the United States to objectively and empirically define SAV community types and to examine differences in abiotic conditions. We defined 12 SAV communities and their abiotic context within the typology of the conceptual state-and-transition model. We believe the process of empirically-derived community types within a conceptual ecological model has wide ranging applications to the management and restoration of wetland ecosystems elsewhere in the world. Furthermore, given the widespread distribution of many SAV species, characteristics of these specific vegetation communities within our study area may be widely relevant.

020.03 - Consumer control in New England coastal wetlands: A shifting paradigm

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Wetland restoration initiatives have been an important component of efforts to safeguard and recover lost and degraded ecosystem services since the mid-1900s. However, studies have shown that, on average, restored wetlands have reduced biological structure and biogeochemical functioning compared to natural reference wetlands. Traditional restoration methods often aim to restore the physical and hydrological features of wetland sites with little regard for the biological features, such as community

structure and species interactions, that may be important drivers of ecosystem functioning. Therefore, the purpose of this study was to evaluate the impact that consumers have on several large-scale processes and contribute to the general understanding of top-down vs bottom-up control in New England tidal wetlands. I established enclosure cages within three coastal wetlands and manipulated the structure of a crab and cordgrass food web to assess how community structure affects ecosystem functions and determine the attendant implications for ecological restoration. Findings show that although consumers may exert some top-down or facilitative effects, other environmental factors may play a larger role in the maintenance of ecosystem processes. These results indicate that the recent consensus on top-down control as an important mechanism in ecosystems with reduced predator populations may not hold universally. This work adds to growing literature indicating a need to evaluate and restore wetland systems holistically, focusing not only on the biogeochemical processes, but also the ecological drivers of function. By doing so, we improve our ability to recover and safeguard the functions of these valuable and threatened ecosystems.

020.04 - Wetland restoration in a large Ramsar-listed treatment plant: Partnerships of science, engineering, management and community

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The Western Treatment Plant treats wastewater for half of Melbourne (~5 million residents). The site covers 10,500 ha of coastal habitats, listed under the Ramsar Convention and protected under Australian legislation. It attracts thousands of waterfowl, shorebirds, cormorants and ibis, and provides habitat for the Critically Endangered Orange-bellied Parrot. Waterbirds have been monitored systematically since 2000 to determine the impact of a major treatment upgrade aimed at reducing nutrient input to the adjacent sea. This monitoring shows the plant attracts over 100,000 waterfowl (up to 70% of ducks counted in Victoria), with numbers fluctuating inversely to water availability inland. Modelling showed that waterfowl and shorebirds benefit from nutrient enhancement of the treatment ponds and adjacent tidal mudflats. Waterbirds remained numerous after the upgrade but one important section of the plant (Lake Borrie) supported fewer birds. Consequently three major engineering projects have been undertaken to restore habitat quality, along with a broader conservation program. A new pipeline was built to deliver partly treated sewage to Lake Borrie. Multiple outlets were built to distribute treated sewage from Lake Borrie more effectively on tidal mudflats. An old lagoon was opened to the sea to restore saltmarsh habitat for the parrot and other saltmarsh birds. Preliminary results show benefits for waterbirds, while meeting water quality standards. Active collaborations between managers, scientists, engineers and the community have been the key to success. Sensitively managed treatment plants can play important roles in waterbird conservation.

020.05 - Wetland conservation and management in Latvia

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Wetlands in Latvia, including raised bogs and fens are influenced by various human activities, like drainage and peat extraction, determining the need of their conservation and management activities. To diminish the drainage influence in wetlands, European Commission LIFE programme projects are implemented in especially protected nature areas. Aim of the projects is to introduce protection and management measures to secure the most favourable conservation status for wetland habitats of European importance. Results of seven LIFE projects starting from 2004 to 2017 are evaluated where positive wetland restoration experience was gained. Prior to implementation of restoration actions, vegetation, hydrological, geological studies and monitoring were performed, including the use of LIDAR data for hydrological modelling. Changes in plant cover and site hydrology, resulting from the water level raise in raised bog habitats in the drainage influenced areas are analysed from permanent vegetation relevés and daily water level data. Results of water monitoring show that after the implementation of restoration actions, water table has raised in the degraded raised bog areas. There is an increase of Sphagnum species characterising more wetter habitats at six months after the raise of water level, while die back of species of drier habitats *Calluna vulgaris* is observed. Drainage ditches are colonised by *Sphagnum cuspidatum*, an indicator species for the improvement of site hydrological condition. Results

of habitat and hydrological monitoring in the LIFE project sites in Latvia show that the raised bog restoration activities have a significant positive effect both on site hydrology and vegetation cover.

020.06 - Riverbank Restoration on Regulated Rivers: Managing ecological function from hydro-power operations

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Water level fluctuations from hydro power operations create a hydrologic regime which is similar to tidal wetlands. Riverbanks are subject to daily periods of inundation, followed by periods of drought. Riparian vegetation must be able to support these daily and weekly water level fluctuations, as well as adapt to floods and natural high water flows. In the northeastern United States, we have developed techniques to stabilize eroded riverbanks and to establish native vegetation using natural channel design techniques and fluvial geomorphic processes to stabilize eroding river banks. We have found that using logs and woody material can both stabilize the riverbanks, reduce velocity, and allow for the establishment of native vegetation. Over the past nine years we have monitored over 65 km of riverbank restoration areas on rivers regulated by hydro power activities. We have used engineered logs placed along the riverbank reduce near-bank shear stress, reduce water velocity, and permit the natural accumulation of river sediment. Vegetation is established on the accumulated sediment, which in turn protects the riverbanks, and creates a natural bank condition suitable for plants and animals, and restores ecological function.

021 Birds as agents and outcomes in ecological restoration

021.01 - Implications of avian-habitats relationship in wetland restoration

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Wetlands located in the suburban areas are important and productive green spaces in the modern landscape, and are also the hotspots for urban biodiversity and ecological restoration research. This paper developed and applied a method for conducting ecological restoration where requisite baseline data is lacking. This method was used in the restoration, landscape design and planning of Qilihai Ancient Lagoon Wetland in Tianjin, China, to improve and maintain habitat conditions and contribute to regional biodiversity. The interior structure, vegetation cover types, habitat patch areas, human disturbance were documented and a multi-species-habitat model was developed to show the relationship between the frequency of occurrence of birds, in different habitat types, in three reference sites. Avian populations, distributions and habitat characteristics were surveyed over a one-year period. Bird were grouped by foraging guild and cluster analysis was conducted to show guild usage of different habitats. In order to identify the detailed characteristics of birds' preferred habitats, 14 variables were selected for assessments by multivariate regression analysis and correlation analysis. It was found that birds were sensible to vegetation density, habitat-patch features, surrounding land-use, human disturbance and water conditions. Accordingly, suitable environment conditions and microhabitat types for each guild were developed. The methodology is generalizable and can be used for the design, restoration and management of analogous conservation areas.

021.02 - Restoring resilience in Tasmania's woodland bird community

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What to restore? is a central question for restoration ecologists. The answer is particularly difficult when considering long-degraded landscapes where clearly defined historical states are often unknown. The Tasmanian Midlands is Australia's second oldest agricultural landscape and a nationally recognised biodiversity hotspot. Here, the University of Tasmania has partnered with NGOs to develop an animal-centric approach to landscape restoration; using data collected from local wildlife to identify those habitat elements most important to restore. The project explores the underlying processes that produce patterns of occupancy and abundance in a range of species, including bettongs (*Bettongia gaimardi*), quolls (spp. *Dasyurus*), feral cats, microbats and the focus of this research - woodland birds. The unique bird community of the Midlands is increasingly threatened by habitat clearing for the installation of large pivot irrigation systems and a rise in feral cat activity following the decline of the native apex predator (Tasmanian Devil, *Sarcophilus harrisii*). We first conducted broad-scale surveys to identify changes in bird populations over the past two decades and provide a baseline against which the success of restoration efforts can be gauged. Then, we used motion-sensor cameras to document nest predation in birds and quantified vegetation structure at nesting sites using handheld LiDAR. Finally, we measured stress levels in birds to understand their own perception of "good quality" habitat. Our results show that providing vegetation structure that minimises risk from nest predation and the management of overabundant bird species will be critical to restoring habitat for vulnerable avifauna in this region.

021.03 - Nutrient inputs by birds and restoration: effects of owls on the vegetation dynamic of a forest in regeneration

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The knowledge about nutrient inputs by birds in terrestrial ecosystems has been focused on fruit and seed dispersion, however nutrient deposition through carcasses, pellets and feces drops needs more attention since these could represent an important nutrient input to the systems too. This study proposes that owls could have an important role in restoration and an important effect on dynamic plants via pellets deposition at roosting sites. Chemical analyses of owl pellets showed an average content of 6% of calcium, 5.9% of nitrogen, and 5.3% of phosphorus. To verify our proposal we are collecting information about nutrients soil, plant growth, plant recruitment and plant mortality in a simulation experiment established in an Atlantic Forest that is regenerating from a past disturbance since 30 years ago, this forest is located in the Serra do Mar State Park, Brazil. The experiment employs a block design with 20 blocks total containing two plots of 50x50 cm each, one treatment plot where 7.4 gr of owl pellets are deposited every 45 days simulating a roosting site, and a control plot. The tendency of the plant growth in treatment plots, based on the average rate, is to increase along the time when compared with control plots. Mortality and recruitment both have no significant difference between treatment and control plots, but the fluctuations rates along the time are bigger in control plots than in treatment plots. These results correspond to one year of experiment, and we are expecting to continue for one year more.

021.04 - Effects of bird movements on seed dispersal patterns in degraded areas

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Predicting seed dispersal patterns is crucial for the management of degraded landscapes and to define conservation strategies, particularly in areas originally covered by forests. Here, we disentangle the effects of fruit availability, bird abundance, and matrix structure on seed rain density and seed dispersal distance into the open matrix of landscapes. Using observed movement data from three common seed-dispersing birds and gut passage times, we fitted a mechanistic model to simulate seed dispersal in virtual landscapes. We show that seed dispersal to pasture cells was negligible beyond 200 m from forest edge, while perches concentrated a high density of seed rain. The presence of perches also increased more than two times the average seed dispersal distance from forest edge into matrix. Abundance of birds was the main factor influencing seed density in landscape matrix. Although many studies advocate on the importance of habitat amount, our study highlights that stepping-stones also play an important role within matrix, promoting connectivity and resilience, which increases the chance of landscape regeneration.

021.05 - Cliff-nesting bird communities in mining areas in Spain: Opportunities for mining rehabilitation

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Cliff-nesting birds colonize quarries and other human created environments. Some bird species in Spain, such as bank swallows (*Riparia riparia*), have very high proportions of their populations linked to extractive areas. However, previous work has often failed to address how important these artificial areas are for the conservation of cliff-nesting birds and how to promote their presence. Twenty-eight quarries were censused for cliff-nesting birds during breeding season in central, South and East Spain, and factors related to habitat selection of these species were studied across several spatial levels (nest, cliff, quarry & landscape). We censused 33 cliff-nesting species, among which the major types of birds present were different species of sparrows, swallows and corvids. Some quarries had remarkable species richness (14 cliff-nesting species), including species that are endangered at a national level. We censused approximately 5500 individuals, and found communities which exceeded several

hundred individuals in a single quarry. Our results show that industrial habitats created through quarrying offer opportunities to enhance cliff-nesting birds. Managing quarries could be an opportunity to recreate a scarce habitat and to improve local biodiversity. Further analysis is being carried out to study habitat selection at community level for cliff-nesting birds at quarries, studying general patterns of abundance and composition of reproductive cliff-nesting birds. This includes the role of different cliff-like structures present at the quarries (cliffs, stocks, buildings and machinery, ridges, etc.) and the surrounding landscape (2 km radius) around the quarries.

S23 Integration of science, application, and practice in updating the model of seedling selection for restoration

Organizers: Anthony S. Davis & Jeremiah R. Pinto

S23.01 - What is a quality seedling: the Target Plant Concept

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Restoration projects often include seedling procurement, planting, and tending phases. These phases are often managed at a coarse level, which does not allow for best-practice inclusion of science-based results that are linked with improved restoration planting success. Decades of seedling research can be used to refine seedling selection to inform decision-making and provide for higher survival and growth rates. This presentation frames the question of how does one define seedling quality into applicable components based on use of the Target Plant Concept (TPC). The TPC identifies plant characteristics that can be quantitatively linked with improved performance after outplanting. This can readily be adopted as a decision-support tool that incorporates variables at the procurement (e.g. genetic source and biological quality), planting (e.g. timing and methods used), and tending (e.g. seedling monitoring and protection) phases to connect the objectives of the restoration project with the best pathway to overcome limiting factors. This results in seedling quality being defined not just on a small number of physical attributes but rather in relation to overall project objectives. Using the TPC as a standard for successful restoration, the procurement of plant material moves from being based on simply identifying a need for seedlings to a more advanced level of resource management. This holistic approach to seedling selection and management has led to demonstrated improvements in plant establishment as well as potentially lower restoration project costs. Subsequent presentations in this symposium highlight specific examples and case studies of the application of the TPC.

S23.02 - Understanding seedling physiology to optimize seedling success

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In restoration and reforestation, nursery-produced seedlings are often used to achieve on-site objectives. The trajectory in meeting on-site objectives can be accelerated through use of appropriate, quality seedlings. Commonly, morphological measures are used to infer quality. It is important to remember, however, that morphological measures are proxies for physiological functioning. The physiological functioning of a seedling on the outplanting site is what truly defines a seedling. Nursery cultural practices lay the foundational building blocks—i.e. quality—on which seedlings rely upon for early establishment and growth. This work looked to characterize the impacts of water availability during nursery cultural practices on the morpho-physiological functioning of seedlings. It was hypothesized that altering water availability to seedlings in the nursery would impact their hydraulic structure and function. When subjected to two watering regimes (“dry” and “well-watered” by nursery cultural standards), both *Populus* and *Pinus* species exhibited trends in biomass allocation, hydraulic functioning, and carbon assimilation—all important attributes that influence outplanting performance. While still preliminary, this work points towards better understanding of specific nursery culture and its impacts on the morpho-physiological functioning of seedlings, especially for those that may be destined toward water-limited outplanting sites. While morphological evaluations are logistically essential for measuring quality in production scenarios, it is important to understand and link the nursery cultural practices that yield morphology to the critical physiological functioning required for outplanting success.

S23.03 - Characterizing root system development in planted seedlings

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In restoration and reforestation, functional root systems are critically important for the successful establishment of planted seedlings. Seedlings will die if they fail to integrate into the soil water profile. Seedlings can integrate through the use of existing, nursery-grown root systems or through new root growth. Using Douglas-fir seedlings, our research examined how existing root volume and new root growth impact seedlings' water status and physiology, as well as their ability to survive dry conditions. We used morphologically-similar, nursery-grown seedlings and excised their root systems to achieve different starting root volume, then grew them under well-watered and water-limited conditions. We measured seedling growth and physiological performance, including indicators of seedling water status. We found that seedlings that started with smaller root volumes can adjust root growth to compensate for lower initial root volume and fewer number of roots, while maintaining hydraulic function. This suggests redundancy in nursery-grown root systems, but the redundancy may be important under some outplanting conditions. Drought-stressed seedlings with smaller root volumes used less water per leaf area, suggesting that water use efficiency may change with root volume at planting and subsequent root growth. A better idea of how root systems perform after planting will inform our understanding about how seedlings respond to conditions at an outplanting site. We are looking to use this information to help make decisions related to container size, seedling stocktype, and nursery cultural practices for the seedlings used in reforestation and restoration projects.

S23.04 - Managing genetic resources to increase restoration success

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Designed for land managers, this presentation will highlight how theoretical genetic concepts can be successfully incorporated into revegetation practice. Examples will demonstrate how important concepts such as genetic diversity and local adaptation directly inform program management and project design. Applied genetic principles will be discussed in the context of seed collection, cleaning, storage, and plant materials grow out and installation. Examples from the Pacific Northwest USA will be presented as a templates for revegetation success. These scalable examples include small "boutique" landscaping projects to large scale revegetation of transportation infrastructure. Throughout this presentation individual genetic recommendations that can be incorporated into any into restoration program with any budget will be discussed. The goal is to provide land managers with discrete recommendations that can be incorporated into their management program individually or as a whole as resources allow.

S23.05 - Improving seedling establishment success through beneficial microorganisms

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Myriad reductionist analyses have demonstrated that the response of plants to shared resources from co-evolved microbiomes can result in adaptive phenotypic changes, stress mitigation, as well as improved plant immunity through direct and indirect mechanisms. This presentation will showcase research providing an assessment of select microbial endophyte consortia for use in improving native conifer seedling growth and development. We evaluated *Pseudotsuga menziesii* and *Thuja plicata* seedlings, established and grown under greenhouse conditions, and through simulated field testing, to determine if colonized plants have improved establishment potential when subject to common stressors including drought and nutrient deficiency. Our experimentation determined that following 1-year post-inoculation, seedlings of both species demonstrate the maintenance of significantly higher physiological performance potential versus a control. If inoculation took place prior to sowing, seedling morphology was significantly different from controls. Improved drought tolerance was demonstrated for both species. Further, evidence from the trials suggests that a healthy seedling nutritional status may be the catalyst for improved plant growth and development when select microbial endophytes are present in *P. menziesii*. Thus, successful inoculation of widely used conifer species with endophytes holds promise for increasing forest productivity and reforestation efficiency; particularly through a

decrease in tending costs during early stand management. Results will inform nurseries, restoration ecologists, and the forest industry on the potential benefits of acquiring and deploying endophytes for improving reforestation success in coniferous systems. Further research may expand to include a greater endophyte consortia (more species) as well as a wide diversity of restoration outplanting conditions.

024 Restoring ecological processes: soil and nutrient cycling

024.01 - Shifts in litter and nutrient dynamics in tropical forest restoration plots over a decade of recovery

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Active restoration strategies, such as tree planting, can facilitate forest recovery by increasing nutrient availability. However, the extent to which these processes change as succession proceeds is not well understood. We evaluated litter dynamics and nutrient availability after five and ten years of recovery in four treatments: natural regeneration (no planting), plantation (entire area planted), tree islands (planting in six patches), and reference forest. Treatments were replicated in 50x50 m plots at five sites in southern Costa Rica. In planted treatments, we inter-planted two native timber species (*Terminalia amazonia*; *Vochysia guatemalensis*) and two naturalized N-fixing species (*Inga edulis*; *Erythrina poeppigiana*). Litter production and overall nutrient inputs were initially higher in reference forest, but after 10 years of recovery did not differ between island, plantation, or reference forest; all treatments were consistently greater than in natural regeneration. Although N-fixing species were utilized, the C:N ratio and N were similar across all treatments in the more recent survey, in contrast to much higher N inputs in plantations at 5 years. Currently, only 11.8% of litter is from unplanted species in plantations, whereas it comprised 46.0% in island plots. Planting an entire plot with a few tree species created a strong legacy effect on nutrient cycling at 5 years, but this effect had largely disappeared after a decade, demonstrating how rapidly nutrient cycling dynamics can change in recovering forests. Although both planting treatments are equally effective at restoring litter and nutrient inputs after 10 years, island plots are more economical to establish.

024.02 - Differences in nitrogen cycling among N-fixing trees in Hawai'i affect community composition

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Nitrogen (N) fixing trees are frequently used to restore degraded ecosystems because they can increase soil organic matter and N availability, yet elevated N increases the presence of non-native species in many systems. We asked how the quality and quantity of the plant material N-fixers produce and the rate at which they add N to the cycling pool differ among members of this functional group, and how those differences affect understory composition. To address these questions, we investigated planted stands of two Hawaiian native N-fixing trees (*Acacia koa* and *Sophora chrysophylla*) and 'natural' stands of an invasive N-fixing tree (*Morella faya*) in burned seasonal submontane woodlands in Hawaii Volcanoes National Park. We measured the relative availability of nitrogen in the soil as well as characterizing the rate and amount of N cycling in these stands both in the field and using long term soil incubations in the laboratory. We found that N is cycled very differently under these three N-fixers and that this correlates with differences in the communities that assemble beneath them. *Sophora* stands were associated with faster N cycling, resulting in greater N availability compared to all other site types, and their understory community was characterized by high exotic cover. We suggest that litter quality may be more important than litter quantity in determining the success of weedy N-loving exotic species in the understory. Restoration practitioners may be able to identify species likely to produce a relatively fast-cycling, high-N environment using N-fixer leaf traits.

024.03 - Restoring oak forests from the bare ground using forest topsoil translocation

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Oak forests are one of the most extended forest systems of the northern hemisphere and provide crucial ecosystem services such as carbon capture, soil preservation, timber production and creation of biodiverse habitats. However, oak forests are threatened worldwide by logging and expanding agricultural frontiers. Once forest cover is removed, soils suffer direct insolation and rain impact, which increase its erosion and lixiviation. In tropical regions, cattle are often free to walk in oak forests and hereby compact the soil and browse the seedling bank. The resulting harsh soil habitat impedes oak seedlings to establish, creating an amplifying feedback that further degrades forest. We tested the importance of topsoil for oak seedling establishment in a Mexican disturbed oak forest. We evaluated germination and growth rates of three oak species both in mature forest sites as in deforested plots with extremely weathered soils. In each site, we placed acorns in patches of native local soil and translocated topsoil from the opposite habitat. Contrary as expected, translocating topsoil decreased germination rates with 10 to 20%, regardless whether forest or weathered soil was translocated. Soil disturbance during its translocation may be interfering with seedling establishment. On the other hand, seedlings consistently grew faster in forest topsoil, and this advantage was even more pronounced when forest litter covered translocated soil patches. While forest top soil translocation failed to increase germination and survival rates, it did improved seedling growth rates. These conflicting pressures on different life stages challenge the design of oak forest restoration interventions.

024.04 - Litter production and decomposition environment is not affected by cluster or isolated seedling planting in early stages of restoration

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The recovery of ecological processes (EP), as litter production and decomposition, is crucial to restore ecosystem functions. Tropical forests restoration has been focused on planting tree seedlings and planting clusters has been proposed to promote EP recovery. However, experimental evidence of cluster effects remains scarce. To assess the effects of planting seedlings - isolated or in clusters - on litter production (type and amount) and decomposition environment, we conducted an experiment in a two-year restoration Coastal-Plain-Forest in Caraguatatuba, SP, SE Brazil. Restoration area (7ha) comprised 27 plots with isolated seedlings (2m distance between them); 27 with clusters (30cm distance between seedlings; 5m between clusters); and 8 control plots without planting. We collected litter monthly during 2-years. We quantified annual litter-fall (W) per plot. We separated the samples into “grasses” (Wg; native from the pasture vegetation prior to the restoration) and “dicots” (Wd; native from the planted seedlings). We calculated Litter Substitution Index, $LSI=(Wd-Wg)/(Wd+Wg)$. We also buried 3 litterbags per plot containing cellulose. We measured mass loss after 216-days. We found higher litter production, LSI and mass loss in planted than control plots (259.39; 250.59 and 120.99 g.m⁻²; LSI: 0.09; 0.09 and -0.31 and remaining mass: 23.98; 17.48 and 46.35% in isolated, cluster and control plots respectively). However, we did not find differences between plots with seedlings isolated and in clusters. Planting seedlings is useful to nutrient cycling recovery in early stages of restoration, creating a favourable decomposition environment and producing litter in higher amount and quality than plots without seedlings.

024.05 - Use of potential species for recovery of degraded soils in Morelia, Michoacán, México

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The use of native species with potential to grow in disturbed sites, could induce the development of protective vegetation that will preserve and increase soil fertility and biodiversity. In this context, planting of five hundred seedlings from *Fraxinus uhdei*, *Bauhinia variegata* and *Pinus pseudostrubus* species with potential for restoration, was carried out in areas with different eco-

logical characteristics: gullies, secondary vegetation and abandoned agriculture, in the Umécuaro-Loma Caliente Micro-catchment, to determine the effect of the site on plant establishment. We find that this areas has soils with different process of hidric, quimic and eolic degradation. Microclimatic features of soil indicated differences in pH, organic material, soil moisture and, differences between nutrients phosphorous, calcium and magnesium concentrations. The difference in photosynthetically active radiation was consistent with the orientation and with the presence of plant cover of each área. Growth of *Pinus* sp. in both height and diameter, as well as its survival, was higher in the gully zone. The plants of *Fraxinus* sp. showed damage due to herbivory, so there was no growth in height in any site, however, the growth in diameter and its survival was higher in the agricultural area. The plants of *Bauhinia* showed high growth in height and diameter and high survival in the agricultural zone. Our results suggest the best species to re-establish gullies areas is the pine, while *Fraxinus* and *Bauhinia*, can be used in sites disturbed by agriculture or with soils compacted by cattle breeding.

024.06 - Nitrogen fertilization during nursery production and protection after outplanting improve restoration of *Nothofagus alessandrii*, an endangered, endemic Chilean species.

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Ruil forests, located in the Mediterranean zone of Chile, have been seriously degraded and fragmented by strong anthropogenic pressure. Ruil (*Nothofagus alessandrii* Espinosa) is an endemic Chilean species officially cataloged as critically endangered and declared a national monument. Although restoration is desired, little information is available regarding nursery propagation methods and silvicultural techniques required to establish this species on potential restoration sites.

Therefore, we evaluated first-year survival and growth of *N. alessandrii* as affected by combinations of container size (130 and 280 ml), nitrogen (N) fertilization (0, 200, 400 and 600 mg N L⁻¹ with the rest of the nutrients constant), and seedling protection (with and without mesh guards) after outplanting them on a site within the species range. Although no significant interactions were observed, our results showed that N fertilization and seedling protection significantly increased survival; fertilization increased survival from 28 to 48% and protection increased survival from a 25 to a 60%. Survival and growth were unaffected by container size. Nitrogen content, rather than concentration, proved to be the better predictor of survival; seedlings with N contents ≥ 25.8 mg (achieved with N fertilization ≥ 200 mg N L⁻¹) survived equally well and significantly more than the control. The most growth was observed in plants fertilized with 600 mg N L⁻¹ (56.2 mg N in plant). The mesh protection guards drastically modified the micro-environmental conditions, reducing the average daily maximum temperature by 8°C and increasing the average daily relative humidity by 20 percentage points.

S25 Assessing and setting priorities for forest landscape restoration to achieve biodiversity conservation targets

Organizer: Cara Nelson

S25.01 - Defining the decision space for landscape-scale restoration of forest ecosystems

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Given the immediate need to meet global forest restoration goals, with near-term targets as soon as 2020, the restoration community is ramping up efforts to develop national and regional forest restoration plans and to develop monitoring and assessment frameworks. Central to these efforts is the need to ensure that activities that are planned and implemented under restoration initiatives are restorative and have the potential for both strong biodiversity conservation and human wellbeing outcomes. For example, ecological restoration by definition aims to repair degraded ecosystems and, therefore, restoration planning at the landscape scale should focus on identifying degraded landscapes. In addition, restoration plans must consider biodiversity conservation and ecological complexity and sustainability, in addition to the ecosystems goods and services of interest to stakeholders. Despite widespread agreement on these principles, the international community lacks comprehensive and widely endorsed guidelines for landscape-scale forest restoration. In this presentation, case studies of assessments of priority areas for forest landscape restoration will be used to explore the need for landscape-level guidelines. In addition, a framework for defining the decision space for ecological restoration planning for forest ecosystems, based on results of the Forum on Biodiversity and Forest Landscape Restoration, will be proposed. The framework and guidelines will provide a tool for decision-makers, stakeholders and scientists to use in both restoration planning and assessment, and will assist with separating ecological restoration and restorative activities from other areas of ecosystem management.

S25.02 - Operationalizing the new international standards: a key next step

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In December 2016, the Society for Ecological Restoration (SER) launched the first International Standards for the Practice of Ecological Restoration: Including Principles and Key Concepts. The Convention on Biological Diversity Conference of the Parties in Cancún, Mexico, was chosen as the venue given its importance in bringing together not only environmental delegates from countries around the world, but also key stakeholders from across the international policy arena who have been instrumental in driving the global initiatives to implement large-scale restoration programs. The International Standards were designed in large part to fill a need for a “common and coherent approach” to achieve restoration-related targets under such initiatives as the Bonn Challenge, the Paris Agreement on Climate Change, the CBD Aichi Biodiversity Targets, the new United Nations Sustainable Development Goals, and numerous other global initiatives. The International Standards emphasize that, while ecological restoration can help deliver needed ecological services such as carbon sequestration, it must also assure biodiversity conservation – a core element of global sustainability targets. One of the necessary next steps is to operationalize the International Standards; that is, to develop and provide the tools which will result in the practical use of the International Standards in restoration projects on the ground, especially in conjunction with FLR activities. This presentation will explore efforts by SER and collaborators to develop such tools, both following the launch and at high-level events organized in conjunction with the 7th World Conference on Ecological Restoration.

S25.03 - National practical guideline of forest landscape restoration for BDMS in Korea

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It is difficult to make a guideline for restoration projects since each of the sites has not only common aspects but also unique characters of their own. However, to implement restoration projects effectively and efficiently, it is important to build a basic concept and procedure for the project managers and decision makers of restoration projects. In Korea, there has been historically a unique and important concept so called 'Baekdu-Daegan Mountain System (BDMS)' and it has been a core concept and area for national conservation of human history and natural environment. A guideline for restoration project has been developed based on not only SER's restoration concept and paradigm but also domestic circumstance in Korea including BDMS concept and area. There are 7 steps: diagnosing, goal setting, planning, suitability evaluating, project implementing, project evaluating, and monitoring & post management in the guideline. Each step has index to check essential features, to evaluate the procedure and to maintain consistency from the beginning to the end of the project. The guideline will be examined in the field since 2017 and the feedback will be used to improve the quality and suitability of the guideline for practical circumstance of restoration projects in Korea.

S25.05 - Forest Ecosystem Restoration by large area plantation in Republic of Korea

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In the early 1960's the Republic of Korea (ROK) was one of the poorest and least developed countries in the world, with a nominal GDP of \$82 (USD) per capita. It seemed unlikely that the ROK could rehabilitate its forests, which had been devastated during the Japanese occupation (1910-1945) followed by the Korean War (1950-1953). Despite the unfavorable economic climate, the Korean government began a massive tree planting effort in 1962 through the newly instituted National Reforestation Program.

From 1962-1987, the National Reforestation Program was responsible for the planting of an astronomical volume of trees throughout the ROK. Erosion control projects were carried out in conjunction with tree planting. The concerted government-led efforts coupled with the public campaign allowed the ROK to become an internationally recognized example of forest restoration a mere 25 years after the program's inception.

Through sharing its experience and lessons learned, the ROK has contributed in helping other nations with similar objectives. Building upon existing efforts; the ROK launched the Forest Ecosystem Restoration Initiative at the CBD COP12 in cooperation with the CBD Secretariat. KFS and the Secretariat announced work plan for the initiative early in 2015 and had multiple workshops under FERI. Adding to this, by supporting FAO's FLRM (Forest Landscape Restoration Mechanism), KFS supports the establishment and implementation of forest rehabilitation plans in the developing countries. FERI and FLRM plan to expand its support for developing countries in need of forest ecosystem restoration.

026 Restoring ecological processes: biodiversity and functioning

026.01 - Is it possible to restore trees and non-trees in high-diversity forests?

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Assessing the success over time of restoring complex ecosystems such as the Atlantic Forest is especially urgent because of the demand for restoration following changes in the current environmental law in Brazil. We studied several parameters of all plant growth forms (418 species) with monthly sampling over 2 years, related to function, redundancy, species originality and resource availability to fauna, plant structure and diversity. Flower and fruit production have been recovered after one decade of restoration, indicating resource provision for fauna. There was wide variation in resource provisioning likely owing to the large number of species used on these projects (> 70 species). We found dissimilar phenology patterns among growth forms, so failure to include different growth forms with complementary phenologies could have a direct impact on fauna that depend on fruits and flowers. Moreover, redundancy, functional diversity and species originality were not related to restoration age. Many structural aspects resembled mature forest within five decades. A highly diverse species pool seems to promise to increase richness and functional diversity of tree species, but even the oldest sites still lacked diversity of other growth forms, particularly climbers and epiphytes. Non-tree recovery cannot be expected as a natural consequence of tree recovery. Hence, specific strategies must be applied to facilitate their restoration and increasing probability of restoring ecological processes and sustainability in restoration sites. Sites in highly fragmented landscapes even the ones that have received adequate investment in high diversity should have continuous adaptive management even after several decades.

026.02 - Reintroduction of epiphytes in forest restoration: Effect of transplant site and seedling size

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Epiphytic plants are fundamental to the structure and dynamics of tropical forests; however, they have difficulty colonizing secondary forests and forest restoration plantations due to limitations on dispersal, germination, and establishment, thus limiting the conservation value of restored forests. Artificial reintroduction of epiphyte seedlings produced in greenhouses may be an alternative to overcome the barriers encountered in natural colonization. In this research, we study the effect of plant size and site transplant of four epiphytic species transplanted into a, 28 years Seasonal Semideciduous Atlantic Forest restoration plantation in southeastern Brazil. We transplanted one araceae (*Philodendron bipinnatifidum* Schott ex Endl), two bromeliads (*Aechmea bromeliifolia* (Rudge) Baker. and *Billbergia zebrina* (Herb.) Lindl.) and one cactus (*Epiphyllum phyllanthus* (L.) Haw). The transplanted individuals were produced in greenhouse under two conditions: nutrient supply and nutrient restriction, resulting in individuals with two size classes (small and large) and were transplanted to two sites (trunk and fork). Survival and growth were monitored for approximately three years. For all four species, the size of the individuals did not lead to differences in the survival rate and the transplant position was important only for *A. bromeliifolia*. Individuals of the smaller class had the highest growth rates, as opposed to the individuals of the larger class that presented high rates of herbivory, possibly due to the higher concentration of nutrients. Future research and monitoring will evaluate epiphyte germination in this and additional sites to determine the generality of our observations.

026.03 - The Use of Ecotypic Plant Collections in Restoration Design to Benefit Pollinator Habitat

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As the majority of native plants require insect pollination for successful reproduction, the recent population decline of native bumblebees, European honeybees, and selected butterfly species threatens the health and resiliency of wildland habitats. In response, agencies and municipalities are actively addressing pollinator decline. Part of the resulting strategy includes the development of native species to increase cover, refugia, and forage habitat. The purpose of this presentation is to discuss the importance of restoration with the intent of promoting native pollinator – floristic relationships for Rocky Mountain ecosystems. Special focus will be made on the promotion and preservation of ecosystem functions and values, as there has been an intrinsic coevolution between pollinators and their respective host flora.

026.04 - Changes in the assemblages of pollination modes among tree communities in conserved, restored and secondary areas of tropical semi-deciduous forest

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We carried out an extensive literature review about the pollination modes of tree species registered in 40 tropical semi-deciduous forests (Atlantic Forest), in order to understand how the diversity of pollination modes vary in relation to the species turnover at a regional scale, as well as between primary, restored and secondary forests. We found that functional dissimilarity was much smaller than species dissimilarity between locations. Functional richness and evenness were not significantly different between forest types, but significant changes were found in the proportions of several pollination modes. Generalized insect pollination was predominant among primary forests, followed by bee, wind and moth pollination; other pollination modes were under-represented. On restored forests, reductions were found in generalized insect, moth, wind, fly, pollen flowers and very small insect pollination, while the species pollinated by bees and bats were increased. Smaller changes were found among secondary areas, including reductions in moth, fly and fig-wasp pollination, while increments in bee, beetle, big animal and small insect pollination. Our results indicate a rather stable assemblage of pollination modes in spite of the high species replacement at regional scale. Major changes among restored forests probably responded to larger disturbance effects and/or restoration practices carried out in these sites, while the smaller changes among secondary forests seem to suggest that highly resilient degraded areas would be more prone to recuperate their functional diversity through natural regeneration alone. Tree communities showed a relatively low diversity of pollination modes; hence, greater diversity among plants with different growth forms would be expected. Efforts in recovering such patterns should be encouraged in order to avoid possible negative effects in plant-pollinator interactions.

026.05 - The restoration of host-parasitoid food webs in rupestrian grasslands

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The restoration of ecosystem functioning represents a big challenge in modern ecology. The identification of which species are key to the restoration process and which can be used when evaluating ecosystem function recovery heavily depends on the knowledge of ecological networks. We compare quantitative galler-parasitoid food webs based on the host plant *Baccharis dracunculifolia*. This species was planted for ecological restoration in different sites and also occurs naturally at nearby reference areas. We contrasted network metrics and community descriptors to assess the recovery of the galler-parasitoid community after ecological restoration, controlling for altitude since it can influence insect community patterns. We found that parasitoids were almost completely specialized to their hosts and that only the metric interaction evenness differed between treatments.

The exclusion of both most dominant parasitoid and galler species from the analyses disrupted the network pattern found. Most community descriptors (species richness, abundance, and parasitism rates) were similar between treatments. However, parasitoid species composition differed between restored and reference sites, whereas galling species from restored sites were a subset of those from reference sites. For such highly specialized galler-parasitoid community, it seems that approaches accounting for species identities can allow the detection of subtle differences. Our results indicate that, contrary to the expectation, higher trophic levels are able to recover rather rapidly. Ecological networks allow accounting for more than each species separately. Restoring host-parasitoid food webs seems possible when there are reference areas nearby; for other cases, connectivity to references might hamper the process of recovery.

026.06 - Light habitat, dynamics and diversity: bases for the restoration of the Tropical Dry Forest, Colombia South America

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The light habitat indicates the amount of energy used by the coverage to perform assimilation and productivity processes which depends on the distribution and quality of the canopy. We consider that this influences the dynamics and the diversity of the secondary succession, which would allow to propose strategies to improve the restoration and conservation of the forest. The research was carried out in the Central Region of Colombia, in four dry tropical forests with different succession states established after anthropic fires. In each forest, permanent plots of 1.0 hectare were established. Light habitat was evaluated at the soil level by measuring leaf area index (LAI), photosynthetically active radiation (PAR) and light extinction coefficient (K). Species density and relative abundance as well as dissimilarity were evaluated. Forest dynamics were evaluated using estimates of growth, mortality, and recruitment. The advanced succession showed lower IAF (1.8), allowing greater availability of resources in the understory ($K = 0.38$), greater diversity of habitats in the vertical space. It has a low growth rate, showing greater stability between mortality and recruitment. Early successions have higher LAI (3.2). Available resources are only at the crown level, generating a higher rate of growth and greater competition for understory communities ($K = 0.57$). There is high mortality of individuals and structural complexity is low in the vertical space. These results point to the need to manage light in early successions to facilitate restoration, encouraging local people to conserve these forests rather than changing land use.

S29 Social participation in restoration projects of Latin America: an expanding field

Organizer: Daniel Pérez

S29.01 - The ecological restoration in Latin America: political and social considerations

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Since colonial times, Latin America and the Caribbean (LA&C) have been subjected to economic, social and environmental pillage. One of the numerous consequences of this past history is that, in 2010, a large proportion of the population of LA&C had incomes below the poverty line, mainly in rural areas. Likewise, it is important to note that LA&C countries returned to democracy only in the last 30 years. With these recent political changes, new collective identities emerged and emanated from old social and ethnic conditions, especially in rural sectors. At same time, this region has vast areas suitable for agriculture and livestock production with relatively low production costs; thus, it generates increasing quantities of food for the rest of the world. However, during the past 40 years, the proportion of LA&C population that lives in rural areas was reduced from 50 to 25%. Therefore, while there are regions with massive deforestation, forests are allowed to regenerate through natural processes where lands are abandoned. In the face of this complex socioeconomic panorama, ecological restoration in LA&C must transcend traditional disciplinary boundaries and offer ecological and human solutions for ecosystem degradation problems. In LA&C, restoration projects should involve, benefit, and empower local residents by offering alternatives that prevent future degradation and that generate new problem-solving strategies that go beyond the ecological discipline by tightening links with the social sciences.

S29.02 - The role of education for achieving conceptual changes required for ecological restoration

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Ecological Restoration based on Environmental Education is defined as ecological restoration efforts intentionally designed with an educational purpose and is included in the major field of environmental education (EE). However, EE could refer to different forms of education. Particularly, in Latin America there is a particular conception of it. In some global interpretations EE it has based on an environment conception where the physical natural context prevails together with recommendations that reinforce natural sciences throughout the corresponding educational levels. In Latin America, EE was developed separately from the formal educational system, with a strong commitment with social claims, rescuing the management of natural resources and the agrarian struggles in rural communities. Thus, in Latin American, a particular conceptual framework with a well established political component was configured. From the Latin American perspective, EE is conceived as a practice to transform a reality? thus, it is not limited to promoting personal actions. In this work, we integrated the methodology of participative action research and communities of practice for establish a new perspective of the Ecological Restoration based on Environmental Education in Latin America.

S29.03 - Training cattle farmers to implement silvopastoral systems and restore degraded lands: The role of innovative producers and pilot farms

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By applying the principles of agroecology to increase the efficiency of livestock production, silvopastoral systems allow the release of marginal lands for ecological restoration. Incorporating trees and shrubs into grazing systems is a key step for adapting cattle ranching to climate change. The Mainstreaming Biodiversity into Sustainable Cattle Ranching Project (MBSCR) applies different tools to accelerate the transformation of small and medium sized livestock farms in five regions of Colombia. Three important strategies of this project are: technical assistance focused on silvopastoral systems, payment for environmental services (biodiversity conservation and climate change mitigation) and capacity building for the sustainable management of cattle dominated landscapes. This talk discusses the role of innovative producers and pilot farms in promoting the cultural change that is required to enhance the management of grazing lands. We discuss Participatory Farm Planning (PFP), a tool that allows farmers to jointly design the productive transformation and restoration of their cattle farms. Pilot farms are essential for farmer-to-farmer training in the implementation and management of silvopastoral systems. Finally, we highlight the synergy between scientific knowledge and the creativity of innovative farmers to adapt the principles of the sustainable livestock production to different agroecosystems. The innovation process draws on the ideas of rural families and workers whose contributions have not been duly recognized by formal science.

S29.04 - Productive restoration: A social alternative in Mexico and Argentina

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Socio-ecological problems are common in rural landscapes in Mexico and Argentina. Productive restoration (PR) is the most appropriate option to deal with them. Agroforestry systems (AS) are a successful PR strategy, as they encourage use of native species that provide ecosystem and socio-economic benefits. AS were established in drylands of Guerrero, Mexico and Neuquén, Argentina as part of PR projects. In Mexico, people conforming the NGO Xuajin Me Phaa mainly cultivate organic jamaica (*Hibiscus sabdariffa*). However, it has lower yields than conventional cropping. To increase production, an AS with *Calliandra houstoniana* was designed. Decomposition of single and mixed prunings of *Calliandra*, *Mucuna pruriens* and jamaica stover was evaluated; also yields was tested by addition or not of *Calliandra* prunings. In Neuquén, Argentina, an AS was implemented with *Atriplex lampa* in a degraded basin. It was evaluated through the Management Systems Assessment Framework that incorporates Sustainability Indicators and interviews with rural settlers. Preliminary results from *Calliandra* indicate both significant differences in decomposition rates when species are mixed and increases in jamaica yield by addition of *Calliandra* litter. On the other hand, *Atriplex* survival was 99% and achieved an average growth of 5% of the initial height. Ninety-percent of farm houses cultivate exotic species for forage and shade. If AS effectively increases yields, they could be adopted by producers who will be directly benefited by means of higher incomes. In both places, landscape matrix is also benefited from presence of tree and shrub species, because they increase connectivity and ecosystem services.

S29.05 - School of Ecological Restoration and its contribution to the social development of ecological restoration in Colombia

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Restoration ecology is a recent discipline, whose purpose is to assist the succession process in degraded ecosystems by different kind of disturbance and poor land management. Based on this definition, since 2002, the Escuela de Restauración Ecológica (ERE) proposed to initiate and promote a formation and organization process that would contribute to generate an ecological

restoration culture in Colombia. To achieve this aim, we developed a strategy to attain a critical and qualified mass to implement of good ecological restoration practices. This strategy was based on several components: 1) generating information networks, 2) offering formal and informal courses, 3) organizing events (seminars, symposia and congresses), 4) implementing agreements with private and public institutions, 5) generating opportunities for the appropriation of projects and to share the knowledge and, 6) producing informative material.

Some of the main results achieved are: a) the Colombian Network of Ecological Restoration (REDCRE, for its acronym in Spanish) creation, and the support provided for the creation of other networks in Latin America, b) 30 formal and 10 informal ecological restoration courses offered, c) more than 500 seminars, two symposia and one international congress organized, d) eight agreements with public institutions performed, and advising the Ecological Restoration National Plan, e) 20 knowledge sharing meetings with rural, corporate and academic communities organized, and f) four books and more than 20 scientific papers published. Today we have a qualified critical mass in Colombia, and the most important thing is that keeps growing.

S30 Bridging the gap between knowing and doing by monitoring and evaluation of tropical forest restoration on a large scale

Organizer: Ciro J. R. de Moura

S30.01 - The Atlantic Forest Restoration Pact (AFRP) effort to create a unifying monitoring method in a national level

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The Atlantic Forest Restoration Pact (AFRP) is a multistakeholder platform, including governmental agencies, private sector, NGOs and research institutions, which aims to restore 15 million hectares by the year 2050, through coordination and integration efforts and actions of its more than 260 members, in order to establish sustainable and economically viable landscapes. To achieve these objective, the AFRP has adopted several governance structures and instruments, which connect and direct actions and stakeholders towards large-scale forest restoration. Under these umbrella is the Monitoring Protocol, an evaluation system, structured hierarchically into the levels of dimensions, criteria, indicators and metrics that should be employed to monitoring forest restoration programs and projects. The system provides a coherent and consistent framework to help check, measure or qualitatively evaluate, at each level mentioned, the desired standard of ecological restoration in the Atlantic Forest. After some years being used and tested for many purpose, the Technical-Scientific Work Group, responsible for studies, analysis, developing technologies and protocols for ecological restoration on PACT, are suggesting a new Protocol, taking into account the need of simplification and operationalization of monitoring process for Atlantic Forest restoration programs. The idea is to keep the framework, setting a minor group of indicators that should provide better information at each criteria. There are also being tested some alternatives methodology to access these data.

S30.02 - Combining scientific and social approaches to monitor degraded and restored forest ecosystems: Lessons from Argentina

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Despite the complexity of degraded and/or restored ecosystems, several monitoring protocols have been developed worldwide over the last decades. However, there is still a lack of a unified tool to allow comparisons. Recently, the LDN-UNCCD program produces a simple methodology based on four global indicators: land cover, land use/land cover (LULC) changes, primary productivity, and soil organic carbon. This facilitates comparisons at the country and sub-national levels, and within ecosystems, but is likely to be limited for local-regional scale projects. In order to contribute with solutions, we summarize the experience from Argentina where forest ecosystems cover 50 million hectares, 89% of which is already degraded. Besides, deforestation rate is currently in the world top-ten list. Since the '90s many long-term monitoring protocols started to be implemented and improved. For example, in the subtropical forest (Yungas), bordering Bolivia, the RedSPP project uses functional and structural indicators in permanent plots. Whereas in the dry Chaco's forests, which also occur in Bolivia, Paraguay and Brazil, indicators are based on potential biomass associated to extensive cattle raising, social benefits and biodiversity. In Mesopotamia, which harbours a gradient of forest types, the APRE project is using a convergent methodology based on LULC dynamics, biodiversity values combining scientific and social records (a participatory monitoring protocol), and economic needs. In our presentation we discuss how these monitoring tools can be combined and applied at different scales and to contribute to policies and decision making (e.g. for a National Plan of Ecological Restoration).

S30.03 - Application of monitoring protocols at large scale

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Although restoration of Atlantic Forest in Brazil has advanced considerably over recent years, intervention methods, restoration supply chain and monitoring all require further development. Field-based ecological monitoring protocols have been created to standardize data collection, based on forest successional stages, as reflected by forest structure and ecological functioning. However, such field-based monitoring of large scale projects is often expensive and inefficient. Remote sensing provides a potentially cheaper and more efficient alternative, but little information has been published about its use and analysis for restoration sites. Therefore, research is necessary to develop its potential. In a preliminary study of Brazil's Atlantic Forest, The Nature Conservancy and partners are analyzing high resolution satellite images, with spatial resolution of 1.5 m, to develop a methodology to determine some soil cover classes, such as cover of forest, grassland and shrubland, in approximately 4,700 hectares of restoration areas. These analyses also allowed evaluation of initial vegetation structure. Further development could improve the method to allow determination of other restoration indicators. Discussions among specialists and decision makers are needed to standardize remote monitoring techniques and facilitate their incorporation into new policies and their use by large conservation programs and conservation movements, such as the Pacto pela Restauração da Mata Atlântica, ultimately to improve the quality of forest restoration projects in Brazil.

S30.04 - Making possible, monitoring, evaluation and management of tropical forest restoration in a governmental agency

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The goal of forest restoration should be to restore forests promoting and strengthening the resilience over time. Despite the efforts, the monitoring of restoration projects by the public power is still incipient. At the Rio de Janeiro State in southeast Brazil, accordingly with the offsetting environmental policy, the control and management of projects are responsibility of Environmental State Agency – INEA. Through a covenant between Petrobras, NGO Sociedade Ecoatlântica and INEA, were developed a methodology for monitoring and evaluation tropical forest restoration. The objective of this work is to present an approach for support the decision makers on the evaluation of the restoration projects in the Rio de Janeiro State. Two protocols were developed. Named as Rapid Ecological Diagnosis (DER) and Rapid Environmental Diagnosis (DAR) both use seven ecological concepts to evaluate restoration of forest biomes with local occurrence. The methods DAR and DER, generate a concept (CF) that vary from zero up to ten. If CF ≥ 8.0 , the project can be approved. The protocols are correlated despite their differences and complexities ($r^2 = 0.9461$). The new protocols generated clear licensing rules, and improved the quality of the assessment system used by the government, and benchmarks for the standardization of evaluation. The monitoring protocols developed are simple, robust, and suitable for local conditions. The correlation between methodologies increased a precision and a scale of evaluation of projects. The regulation of the presented protocols and management tools are elaborated and institutionalized in the restoration in a subnational level.

S30.05 - Ecological restoration monitoring in the State of São Paulo: Making it simpler and more comprehensive

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Mandatory restoration, public-funded initiatives, biodiversity offsetting, and other mitigation actions all require measurability and criteria to assess the outcomes of ecological restoration efforts. This assumption has important implications in Brazil, where the so-called New Forest Code (Federal Law 12.651/2012) requires that some areas within a rural property shall be conserved, if covered with native vegetation, or restored, if degraded, through landowners' formal commitments. Generally, subnational gov-

ernments are responsible for verifying that restoration projects carried out by farmers and practitioners comply with regulations. In this context, the innovative approach implemented by the São Paulo State government to verify whether the targets of those projects are being achieved, and fulfill pending legal requirements, represents a ground-breaking policy regarding monitoring and legal frameworks. A set of three simple and integrative ecological indicators, namely i) ground coverage with native vegetation; ii) density of native plants spontaneously regenerating; and iii) number of spontaneously regenerating native plant species, will be measured until each restoration project under review attains the expected results. A maximum time limit of 20 years is adopted, and a monitoring protocol is employed that can be applied by landowners as easily as by specialists.

We analyze preliminary results from a first major monitoring assessment that covered more than 1.000 hectares using the above-cited protocol - encompassing two hotspots, Atlantic Forest (Mata Atlântica) and Cerrado (Brazilian savanna) biomes - in line with the Atlantic Forest Restoration Pact (AFRP) and with constructive contributions from the Ecological Restoration Brazilian Network (REBRE).

S31 The use of scenarios and models in ecological restoration

Organizers: Karen Esler and Jean-Paul Metzger

S31.01 - Systematic mapping of biodiversity and ecosystem services scenarios research applied to landscape restoration

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Effective restoration policies need to take into account the dynamism of land/resource exploration as well as uncertainties of future climates and land use changes. Scenario-planning provides robust and reliable information to account for multiple potential tendencies related with human activities and climate; becoming useful to support environmental decision making process. However, there is a lack of assessments about the use of scenarios, particularly in the context of landscape restoration. Thus, we developed a systematic mapping of evidences to verify the state of science on this issue: We surveyed the Scopus database searching for studies using scenarios applied for restoration. We selected and categorized relevant publications by: main objectives, cost, time, type, and focus of restoration; level of organization, country, scales, climate and types of environments; IPBES scenarios; use of participatory approaches and mains agents. We found a predominance of studies using “exploratory scenario”, dealing mainly with active habitat restoration at broad scales in temperate environments. In addition, the main actors were researchers doing non-participatory studies, mainly at the landscape level and on forests interfaced with crops. We identified a lack of studies at national-to-global scales, as well as a small representativeness of studies declaring restoration time/costs. We found a small amount of publications related to invertebrates, and developed into urban, polar and coastal/marine environments. Our results pointed out important research gaps in the application of scenarios for restoration purposes and also detected a demand for governmental participation on restoration initiatives as an active actor, beyond providing financial support for research.

S31.02 - Scenarios and models as tools for promoting effective restoration actions

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Scenarios and models are important tools to facilitate the communication between scientists and practitioners, and thus to support policy decisions. Particularly, the use of these tools to plan restoration actions has an enormous potential to reduce restoration costs and optimize benefits, but this potential remains poorly explored. Here, we provide guidelines to stimulate the use of scenarios and models for restoration. We argue, first, for the inclusion of a participatory process that captures the aspirations of multiple stakeholders along the whole scenario building process, from scenario planning to the implementation and review phases. Second, restoration outcomes (or outputs), should be defined by key-actors (those who have direct interests in restoration), within a clear socio-ecological context and under a well-defined problem statement, considering a broad range of nature and human benefits that can be derived from restoration. Third, methodological choices, such as scenario type, spatial and temporal scales, drivers and restoration-related variables, should be defined according to the multiple desired outputs. Fourth, we encourage the consideration of the interactions among variables, within a spatially explicit, and temporally dynamic approach. Fifth, results' analysis and dissemination should highlight the tradeoffs and synergies among different outputs, identifying scenarios that maximize synergies and minimize tradeoffs for all objectives. Finally, promoting capacity building, along with a wider consultation process and dialogue with a broader group of stakeholders is critical for the successful implementation and review of restoration actions. Scenarios and models that support restoration should follow an adaptive process, aiming to continuously improve restoration actions.

S31.03 - Exploring scenario and modelling approaches in an ecosystem service based initiative to clear invasive alien plants – the case of Working for Water in South Africa

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The Working for Water programme (WfW) is a long-running South African government ecological restoration initiative designed to simultaneously control invasive alien species and create employment. A key motivation for its establishment was the realization that invasive species have significant negative impacts on ecosystem services, in particular water supply. Using a mixed-method approach, including a content and document analysis of WfW-related academic research, and internal meeting minutes and interviews, we investigated the extent to which WfW has relied on scenarios and models to support its planning, design, implementation and review phases over its 22 year history. We found the use of models and scenarios has been sporadic. As time has progressed, so has a realization of increased levels of complexity. This has resulted in a need for an integrative understanding of social and ecological drivers that requires the effective use of models and scenarios across a range of institutional contexts, scales and time periods to focus investment.

S31.04 - The potential for using scenarios when developing national strategies for restoration in the Nordic countries – with a special emphasis on stakeholder participation

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Committed by the Convention of Biodiversity and the Aichi targets the Nordic countries currently put increasing emphasis on restoring ecosystems affected by habitat degradation. It is an upcoming strategy to develop national plans for restoration, often organized by ecosystem types. This work call for priority models to optimise available economic and human resources, and to minimize level of conflicts. Such priority models has up to present, been used rather randomly, and ranging from scientific and quantitative approaches to more opportunistic and site specific decisions. Introducing systematic scenario work is expected to improve the strategic work of restoration further, by exploring trade-offs, synergies, possibilities, and extremes from different priorities and choices. In spite that the Nordic countries hold relatively low degradation levels compared to more populated areas, parts of these landscapes today are under heavy influence from habitat degradation and climate change is expected to accelerate the negative effects further. Pressure on biodiversity and the need for restoration is increasing in most ecosystem types. We have assessed and considered to what extent scenarios have been used as a tool in Nordic restoration in general, and for the development of national plans more explicit. We found that scenarios only occasionally have been a part of the work. Based on this finding we have elaborated the potential for improved planning and better restoration if participatory scenario-work is used systematically when developing restoration strategies and plans. The conflict reducing effect of participatory processes gets a special focus.

S31.05 - A flexible, multicriteria modelling approach to prioritise restoration aiming at maximising multiple benefits and minimising costs: a case study for the Atlantic Rainforest

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In order to deliver the most efficient outcomes for humans and nature, the various recent restoration targets from local to global scales should take into account the spatial heterogeneity of socioecological systems. Spatial prioritization approaches have been developed for conservation objectives over the past two decades, but similar efforts for restoration are relatively new. We developed a novel multicriteria spatial prioritization algorithm based on linear programming for prioritizing restoration in space in order to deliver multiple benefits while minimizing multiple costs. We apply this algorithm to the Atlantic Rainforest, one of the world's most degraded and fragmented biodiversity hotspot, and one that host two-thirds of Brazil's human population. We focus on maximizing the benefits for biodiversity conservation, climate change mitigation via carbon sequestration and on min-

imizing restoration costs and conflicts with agriculture (measured as opportunity costs). We developed scenarios in partnership with the Brazilian Ministry for the Environment, and focus on the 5.2 million hectares estimated to be restored for compliance with the revised “Forest Code”. We find that spatial prioritization significantly increases the cost-effectiveness of restoration in relation to random allocations or those that minimize costs only. We further shed light on key trade-offs between biodiversity conservation and climate change mitigation, which might deliver important lessons even outside the restoration context. Finally we capture for the first time the economies of scale and their impact on spatial prioritization of restoration, showing that larger projects are preferable from both an ecological and economic standpoint.

032 Community engagement in ecological restoration: planning

032.01 - Landscape Conservation Cooperatives: Linking science, management, and strategic planning across North America

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Given the expanding scale of ecological restoration projects around the world and international commitments to achieve global ecological restoration targets, such as Aichi Target 15 and the Bonn Challenge, there is an increased need to strategically install transboundary environmental governance institutions. Ideal institutions can transform collective interests into collective action and foster collaborative, but also efficient, planning and implementation across geopolitical boundaries. Landscape Conservation Cooperatives (LCC), created in 2010 by the US Department of the Interior to better integrate science and management and address climate change and other landscape scale issues, can serve as a model of cross-boundary collaboration. Currently, twenty-two LCCs span North America, each developing unique solutions to complex issues, but all guided by common values of collective impact, collaboration, moving beyond boundaries, and promulgating science-driven management. The stakeholder-driven approach of the LCC encourages generative dialogue between practitioners, scientists, and decision-makers, and catalyzes innovative solutions that account for multiple scales in complex socio-ecological systems. I will discuss the shared governance structure that underpins the LCC approach and present a case study detailing how the Upper Midwest and Great Lakes LCC is using this approach to produce a blueprint for more strategic restoration and conservation across the Great Lakes, the largest freshwater system on earth. I will explore lessons we have learned about solving complex issues, linking conservation and human wellbeing, and producing science in support of management, specifically as it relates to the challenges of ecological restoration on a global scale.

032.02 - Management and governance strategy for Lake Chapala sub-basin restoration. The use of a Multiple Participation Platform tool.

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We structured a management and governance strategy using a Multiple Participation Platform as a tool for the restoration of the Lake Chapala sub-basin. We analyzed causal elements related to point and nonpoint pollution. Because agriculture was the main activity, interviews and surveys were conducted to governmental officials and producer associations to document issues about crop types and application of agrochemicals and the identification of problems and solutions. The main problems were: poor water quality due to sewage, indiscriminate use of agrochemicals, deforestation, and solid waste. We identified 330 sites of point pollution and, as part of diffuse pollution, six major fertilizers, 16 herbicides and 21 pesticides (including the toxic methyl parathion and aldrin). Productive units of small property size (1-6 ha) showed little organization with differential development of the productive practice, use of agrochemicals, and sub-optimal access to monetary supports. We identified 56 key players from different organizations and found 11 main problems. About the posture by social sector, farmers largely rejected reducing the use of pesticides and fertilizers. In contrast, there were opposing views from organic farmers and civil society organizations. In the implementation process, we identified the lack of coordinated actions. We can implement the multi-stakeholder platform, as long as the issue of contamination is established with the agricultural sector in terms of reducing poverty and health risks, improving agricultural profit margins and avoid ecosystem impacts. We identified six lines of action: information, infrastructure, institutional management, research and monitoring, environmental conservation and restoration and technological innovation and credit.

032.03 - Methodological challenges in inclusive ecological restoration: Two contrasting case studies from India

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Ecological restoration projects need to incorporate societal choices and concerns to the extent ecologically tenable for long-term sustainability. However, eliciting societal choices and including them in restoration planning creates twin challenges for inclusive restoration. This study provides a comparison of two restoration projects from India; one located at an iron-ore mine-spoil in Odisha, and one that of an urban wetland in Delhi, both of which engaged in detailed evaluation of choices of the local community regarding restoration targets. The aspirations of the urban neighborhoods and traditional forest communities in these projects were mapped using Choice Experiments in which restoration scenarios were presented as alternative 'choice bundles' of ecosystem services. While both the ecological and social contexts varied, it was observed in both cases that ecosystem functions and biodiversity conservation did not emerge as clear choices. This seemed counter-intuitive since it was hypothesized that the urban society as well as the traditional forest dwellers would aspire towards ambitious ecological restoration goals. The societal choices across ecosystem services, indicate trade-offs favoring provisioning services that provide direct use values as opposed to regulating, supporting or cultural ecosystem services. The overall outcomes indicate that while methodological challenges of eliciting societal choices could be addressed effectively by innovative approaches, resolving the gap between societal aspirations and ecological goals pose formidable philosophical challenges.

032.04 - Restoring rainforest in Madagascar: Are we planting enough trees for people and lemurs?

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Rainforest restoration is vital for reversing current trends of deforestation and for maintaining remaining habitat for Madagascar's unique wildlife, including its >100 emblematic lemur species (90% of which are threatened by extinction). We have therefore introduced reforestation and ecological restoration programs as a conservation tool to be implemented by local communities managing various lemur-rich rainforest sites in eastern Madagascar under government-backed management transfer schemes. In order to overcome initial scepticism of the need rainforest restoration, we have integrated community members in assessing the impact of current forest use on resource availability and ecological services. We used spatial analyses to map forest evolution and correlate it with human demographics in order to run simulations of potential future scenarios. In order to reach a high level of accuracy, we have collected data on the number of cut trees and the amount of other forest products consumed per year. Based on these findings, we calculated the expected number of trees to be planted each year in order to keep the rainforest and its ecological services from shrinking. As a result, motivation among the local community to engage in rainforest restoration and tree planting has considerably increased, which has helped us to set up a comprehensive rainforest restoration program aiming at both maintaining the local community's resource base and securing crucial habitat for endangered lemurs.

032.05 - Restoring natural processes in two culturally important Natura 2000 sites in Romania

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This study is located in the central part of Romania, in two Natura 2000 sites of community importance Fortress-hill Lempes-Harman marsh (ROSCI0055) and Forest and eutrophic marshes from Prejmer (ROSCI0170). The two sites are very important on the one hand for the cultural value (the villages from the vicinity: Harman and Prejmer were established around the 13th century, and were inhabited by the Teutonic knights), and on the other hand due to natural value (water supply was permanently assured from the two marshes). Hydrological and pedological mapping was conducted for the marsh habitats, the drainage system was improved, the invasive plants were removed and grazing was forbidden. Fencing the threatened habitat 7120* with a green fence, reinforced by permanent meetings with farmers, animal breeders, mayors, authorities for environment protection, before grazing

period, in order to eliminate/reduce it from the marshes facilitated also natural restoration. Likewise, patrols for grazing monitoring, ecological education/volunteering campaigns with children and students and setting up picnic areas - thematic tracks for tourists were implemented. After a 5-year period the level of ground water was improved, community plant species were reinstalled (*Liparis loeselii*, *Ligularia sibirica*, *Adenophora lilifolia*) in the depreciated sections of the marsh; an improvement in floristic composition by the appearance of new species was facilitated, communities were informed and they want to be more involve into management actions, likewise compensations were payed for some of them. All the concrete active measures have contributed in restoring the natural processes and for ensuring long-term conservation.

033 Restoration of tropical savannas and grasslands

033.01 - Evaluation of community translocation as mean of conservation of copper-cobalt ecosystems using a plant trait-based approach

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Classification of species according to plant traits related to functions is now largely recognized as a tool to predict plant community responses to disturbances or restoration treatments. Using plant trait-based approach to assess community translocation success can bring new insight to understand restoration of plant communities and to understand why some species can fail to be translocated. Our study took place in southeastern Democratic Republic of Congo. Using some traits, we aim to evaluate community translocation projects of three hills, which were set up to conserve two kinds of metallophyte communities, the steppe and the steppic savanna. Objectives are to assess over two years i) how plant communities change over the first years after community translocation and ii) identify which kind of species are present or missing in the translocated communities. For the three projects, translocated communities were different from communities in reference ecosystems and dissimilarities between reference and translocated communities tend to increase with time, which imply changes in community structure. Forbs and graminoids cover did not draw general trends among hills along time as we usually observed a significant interactions between hill and time. In both communities, for the three projects, species with xylopodia and with a more developed underground system (i.e. superior to 30cm depth) were under-represented in translocated communities. Large underground systems are characteristics of tropical old-growth grasslands and new strategies to improve restoration of Cu-Co, including introduction presenting large underground systems, needs to be promote.

033.02 - Direct seeding of native trees for restoration of the Cerrado biome in abandoned cultivation area: effect of groove depth and fertilization

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Few studies have been conducted in direct seeding of native species, so it is important to identify the capacity of each species and the soil characteristics in the success of seedling emergence of important species for restoration. This study evaluates direct seeding on seedling emergency of 10 woody species of economic use of the Cerrado biome after. The study was developed in abandoned cultivation area at Fazenda Entre Rios at Distrito Federal. The experiment was carried out in blocks with four repetitions of four treatments: T1: no fertilizer, deep furrow; T2: with fertilizer, shallow groove; T3: with fertilizer, deep furrow; T4: no fertilizer, shallow groove. Each experimental unit was composed of 30 seeds of each species in lines of 30 meters in length. Sowing was carried out in November 2012 in the beginning of the rainy season and the seeds do not have undergone any treatment to break dormancy. Seedling emergency rate varies among species with lower figures for *Guazuma ulmifolia* Lam. (0,7 %) and higher for *Eugenia dysenterica* (Mart.) DC. (44,5%), *Dipteryx alata* Vogel and *Copaifera langsdorffii* Desf. (38,1%). The ANOVA mean effect showed no significant difference among blocks ($p = 0.09$) and treatments ($p = 0.69$) for any species, which shows that the depth of the groove and the fertilization performed do not affect emergence of seed of the species considered. (Project Biomes, ProIC/DPP/UnB).

033.03 - Savanna restoration using direct seeding: there is an ideal seed density?

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The control of invasive grasses and introduction of native propagules are essential to restore grassland and savanna ecosystems. We tested the effects of ground cover species seeding densities in direct seeding restoration experiments within the Brazilian savanna, Cerrado. The experimental area was dominated by invasive African grasses and were mowed and plowed twice before seeding. We seeded 22 grass, forbs, shrub and tree species (mean seeding density of 1.8 viable seed [VS]/m²) accompanied by seven ground cover species seeded in three densities (Low [1/2M], Medium [M] and High [2xM]: *Aristida gibbosa* (grass, M = 48 VS/m²), *Lepidaploa aurea* (shrub M = 129 VS/m²), *Achyrocline satureioides* (shrub, M = 17 VS / m²), *Stylosantes capitata* and *Stylosantes macrocephala* (shrubs, M = 65 VS/m²), and *Solanum lycocarpum* (shrub, M = 6.5 VS/m²). Each treatment was applied to three randomized plots, we also established three control plots where no seeding was performed. We evaluated ground cover through line-intercept method by grouping species into functional groups and analysed the data using generalized linear models. After two years, all restored plots had higher native species cover than control plots with an average 4.5 saplings/m². The seeding density treatments did not result in significantly different ground cover by natives nor invasive species. Our results indicate that even our low density seeding treatment was enough to re-establish native plants in the first two years. High seeding densities may increase competition of native species against invasive grasses and therefore increase restoration effectiveness.

033.04 - 14 years after the deposition of sewage sludge in a degraded area in the Brazilian savannah: Is the rain of seed and litter deposition reestablished?

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The deposition of sewage sludge in mined areas is an anthropic intervention that has been adopted to increase fertility and incorporate organic matter into the mined substrate, and give a suitable destination to this residue. However, only the deposition of sewage sludge may not be sufficient to restore the ecological balance of the degraded area. The objective was to compare an area covered with sewage sludge submitted to a rain of seeds and litter deposition with the adjacent area of savanna natural vegetation (Cerrado). The study area (15° 57'00.10"S, 48° 10'37.96"W), in 2002, received sewage sludge deposition after the closure of the mining activities. In 2016, 30 collectors for litter and rain of seeds were distributed in five blocks with six replicates. Three blocks were placed in the mining area that received sewage sludge and two in the adjacent Cerrado area. The collectors remained in the field for 60 days, the litter were weighed, and the seeds counted. The data were submitted to Principal Components Analysis, in which is possible to verify (axis 1 explaining 75% of the variance) that the blocks of the mined area form a group that differs from the blocks of the Cerrado, which, in turn, presented higher amount of seeds and deposited litter. Thus, even after 14 years, the deposition of sewage sludge was not enough to reestablish the ecological pattern of seed dispersion and litter deposition. Therefore, there is a need for another intervention that accelerates the process of ecological succession in the study area.

033.05 - Tree sapling survival to fire in recently restored savanna areas

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Savanna environments are frequently subject to fires. Savanna tree species present fire-resistant features such as thick barks, which isolate high temperatures; and high investments in below ground structures associated with underground buds, which allow for resprout from underground tissues after topkill. Most savanna trees are slow growing and very little is known about young saplings' resistance to fire, since small plants can be several years or decades old. We followed the survival and growth of saplings from 20 Brazilian savanna (Cerrado) tree species before and one year after fire. We studied saplings that were two (n=1,553) and three years old (n=595) when burned. We compared plants' performance to unburned saplings (n= 1,136) of the same

age and areas. Survival rates varied from 10 to 96%. For most species, fire treatment did not affect survival rates. The survival of two years old saplings, *Eugenia dysenterica* was higher in burned treatment compared to unburned, probably due to decreases in competition for light against invasive grasses after fire. The two fastest growing species, *Tachigali vulgaris* and *Solanum lycocarpum* were the only species with increased mortality due to fire. Two years-old burned saplings mostly recover pre-fire height one year after fire, but were significantly smaller than unburned saplings of the same age. In contrast, most saplings burned at three years of age reached similar heights to unburned saplings of the same age a year after fire. These results show high fire resistance of savanna tree species at very young ages in restoration sites.

033.06 - The need for restoring fire regimes in Cerrado: 30 years of degradation from fire suppression

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Tree encroachment into savanna is a global phenomenon. In recent decades, the Brazilian Cerrado faces a degradation process caused by fire suppression. This work was carried out at the Santa Bárbara Ecological Station (SP, Brazil) in a mosaic of Cerrado and Atlantic Forest. To quantify the degradation from fire suppression and to prepare for restoration of fire regimes we characterized plant communities in 30 permanent plots (20 x 50m) distributed over three savanna-forest transitions in *cerradão* (forest), *cerrado strictu sensu* (dense savanna) and *campo cerrado* (open savanna). Our findings reveal that under fire suppression species adapted to fire were largely replaced by forest species, decreasing the richness of savanna species by 69%. The loss of shrubs, forbs and graminoids was most acute when vegetation reached a basal area of approximately 15 m² ha⁻¹ and a LAI of 2.5, a threshold that roughly corresponds to the transition between dense savanna and forest. This was associated with threshold of flammability, beyond which the restoration of fire regimes is impeded, since the disappearance of the species-rich herbaceous layer reduces the flammability of the system. Specifically, fire burned consistently in *campo cerrado*, was irregular in *cerrado sensu stricto*, and failed altogether in the *cerradão*. It is not yet clear whether it will be possible to reverse the disappearance of endemic fauna and flora following forest encroachment, so management should prioritize restoration of fire regimes in Cerrado well before substantial change has occurred.

S35 Interactions between ecosystem restoration and water related ecosystem services

Organizers: Silvio Ferraz and Giselda Durigan

S35.01 - Understanding effects of forest restoration on stream flow at catchment scale in Atlantic Forest region

SILVIO BARROS FERRAZ; CARLA CRISTINA CASSIANO; ALINE FRANSOZI; CAROLINA BOZETTI RODRIGUES; LARA GABRIELE GARCIA; WALTER DE PAULA LIMA

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Following Brazilian restoration goals, more than 1 million of hectares will be restored at Atlantic Forest biome. Many sectors of society have high expectation about benefits on water provision and regulation by forest restoration, since there an association between native forest cover and quantity of clean water. Considering this context, it is necessary to increase understanding the effects of forest restoration on hydrological processes and, consequently, on water resources in tropical region. We used field data obtained by experimental catchments covered by on growing native vegetation and forest plantations (Pinus and Eucalyptus) to understand effects of active forest restoration at Atlantic Forest region. Effects of conversion to forest on hydrological dynamics vary according to forest growing rate and relative position of forest on topographic position. The forest cover establishment is not directly linked to hydrological processes recovery, and the time lag depends on ecological condition of new forest, historical land-use and local natural physical characteristics. Positive effects of forest restoration on hydrological regime is expected on long term, when stream flow regulation is achieved, compensating the short-term effect of stream flow reduction. A framework of forest restoration effects on water resources at catchment scale is proposed and discussed.

S35.02 - Soil hydrological responses to ecological restoration at Atlantic Forest

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Very little information is found in the literature dealing with forest conservation, management and restoration about the mechanisms that regulate biodiversity. In this context, we can insert the studies on soil-water-native vegetation relations. The knowledge of how soil interacts with native vegetation and vice-versa is fundamental for the definition and characterization of the mechanisms that influence the development and distribution of species in a forest, as well as their resilience and sustainability. Many studies done in different forests of the world have shown that a close relation exists between the local edaphic attributes and the richness, distribution and variety of species of a forest. The addition of soil hydro-physical functioning studies to the soil-vegetation relations results in a much broader panorama of how the soil's natural dynamics affects vegetation. We emphasize that the soil is not a static system and that its dynamics affects many natural cycles. Therefore, the inclusion of soil functioning studies aims to understand the relations between soil physical, chemical and biological attributes that characterize different soils and affect the soil water dynamics (flow and retention) and its availability to plants, nutrient dynamics, as well as the capacity to sustain forest, among others.

S35.03 - A global meta-analysis of the relation between forests cover and water runoff, evapotranspiration, infiltration, and soil percolation

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Maintenance of hydrological functions that occur in natural ecosystems is crucial for ecosystem services supply and thus for human well-being. This has become particularly important in the forest landscape restoration context, giving recently regional and national initiatives leading an increase in forest cover in several regions worldwide. Forests sustain several hydrological functions that derive in a wide variety of services, and this vision has based decision making on forest management. For instance, forest management for water provision and regulation has been a major challenge in the field of conservation and restoration in many countries. Considering the growing pressure on forests and water resources, this study seeks to provide information to better understand the ecological aspects of the forest-water relationship. Using meta-analysis, we analyze the effects of land cover changes (i.e. from forest to other cover types) at global scale on four hydrological processes: runoff, evapotranspiration, infiltration and soil percolation. We found unbalanced information for each hydrological process and land cover change. We also found much uncertainty when estimating impact on processes. Exploratory analyses suggest infiltration as the most impacted process, being considerably lower under other cover types than forests. We'll use random meta-analytic models and compare different linear mixed models to evaluate synergies and/or conflicts between these processes. Our results would be useful to construct conceptual frameworks to compensate for the consequences of land-use changes and to guide future conservation and restoration projects, as well as subsidize schemes of payment for environmental services.

S35.04 - Does forest restoration will improve soil infiltration rates on Atlantic Forest?

ALINE APARECIDA FRANZOZI; LARA GABRIELLE GARCIA; PEDRO HENRIQUE SANTIN BRANCALION; MIGUEL COOPER; NAYANA ALVES PEREIRA; SERGIO ESTEBAN LOZANO BAEZ; SILVIO FROSINI DE BARROS FERRAZ

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As many ecosystem services have close relation with forests, conservation of remaining forest fragments and the ecological restoration have been largely encouraged in Atlantic Forest region. It is not expected that new forests offer services at the same level that a conserved forest, but to know if occurs an improve on hydrological services it is necessary to understand better the recovery of these processes after forest restoration. Infiltration is a key process, but the time required to perceive the hydrological response is still not known, neither how much it is possible to recover from a total that has been lost. It is much linked to soil condition, what represent past land-use and its interaction of development of new vegetation along the time. We assessed infiltration processes on plots of forests in processes of restoration at different structures conditions using Beerkan Estimation of Soil Parameters through Infiltration Experiments, referred as BEST. The study was conducted in a pasture matrix landscape and Atlantic Forest fragments in São Paulo State, Brazil. It was expected that forest structure would be related to infiltration rates, however, there are a sort of interacting factors like historical condition, soil resilience and forest ecological condition that influence and modifying infiltration rates and its response to restoration. Those factors and missing information are discussed seeking to understand hydrological effects of forest restoration.

S35.05 - Applying spatially explicit modelling of stream flow regulation for the prioritization of watershed restoration

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The ecosystem service of water flow regulation has been widely recognised as one of the most essential for human well-being. Detriment of stream flow regulation (SFR, also defined as mediation of liquid flows by CICES) has been associated with land use change and extreme events (droughts and floods) under erratic interannual climate variations. However, few studies have attempted to understand the spatio-temporal dynamic interaction between ecosystem types and rainfall regimes to prioritise watersheds for ecological restoration interventions. We applied a spatially explicit model (N-SPECT) in GIS with the purpose

of analysing how the potential of SFR can be negatively affected by land use change at watershed scale. The study area corresponds to a highly dynamic landscape currently dominated by industrial plantation of exotic tree species. Extreme rainfall scenarios recorded in the last 20 years were used to compare water fluxes across watersheds in the study area. We identified an interaction effect in the proportion of shrublands, forest plantation and native forest on SFR. As forest plantations and shrublands increased, there was a negative relationship between native forest cover and SFR. This relationship became stronger when forest plantations cover increased in the watersheds. Overall, watersheds covered by less than 20% of native forests exhibited extreme variations of stream flow. We suggest that restoration actions should be applied in these watersheds in the short-term in order to avoid extreme variations of stream flow, with negative effects on humans.

S35.06 - Savanna structure, functioning, and water-related ecosystem services: drivers for restoration and management

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Re-establishing ecosystem services - ES have recently become a major goal for restoration interventions in the whole world. The relative relevance of each ES, however, varies among regions, depending on biophysical and socioeconomic factors. This presentation will address some trade-offs between ES, such as carbon storage in the biomass x water yield and groundwater recharge, with strong implications for restoration decisions in savanna regions. Besides this trade-off, it will be highlighted that the benefits from carbon storage are limited (carrying capacity), diffuse and not perceived locally, while the benefits provided by restoration in terms of water quality and water yield are permanent and direct to people living in a particular watershed. Savannas are characterized by a long dry season, being fresh water a naturally scarce resource of extreme importance for people and wildlife. Restoration planning and adaptive management must consider that the water-related ES strongly depends on vegetation structure. Evidences from ecohydrological studies have shown that increasing woody density and biomass by planting trees (afforestation) will inevitably increase rain interception and transpiration, thus jeopardizing the recharge of groundwater reserves, springs and water bodies in savannas or semiarid regions. Savanna restoration, therefore, must include recovering the grassy ground layer to avoid surface runoff and keeping low woody biomass to maintain the efficiency in water yield. Being fire a natural force keeping the savanna structure, fire management shall be incorporated in savanna restoration to maintain the hydrological processes and the water-related ES.

036 Tropical and subtropical forest: passive and active restoration

036.01 - Lessons learned about applied nucleation as a tropical forest restoration strategy

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Developing restoration strategies that accelerate successional processes and are resource-efficient is critical to facilitating tropical forest recovery across millions of hectares of deforested lands in the tropics. One such approach is applied nucleation (i.e., planting patches of trees) which simulates the natural recovery process and requires less resources than planting large areas with trees. We report on a long-term study comparing applied nucleation with both natural regeneration and a plantation-style tree planting approach at 12 sites in the premontane wet forest zone of southern Costa Rica. Over the past decade we have measured soil and litterfall nutrients, above-ground biomass, canopy cover, seed rain, woody seedling recruitment, bats, birds, arthropods, and epiphytes in restoration plots and adjacent reference forests. The synthesis of our scientific results and practical experience supports several conclusions about the efficacy of applied nucleation as a restoration approach. First, applied nucleation and plantation restoration strategies are similarly effective in enhancing the recovery of most ecosystem functions and floral and faunal groups, as compared to natural regeneration. Second, there is a minimum island size (approximately 100 m²) necessary to attract seed-dispersers, shade out grasses, and ameliorate microclimate conditions. Third, in our study the tree island cover has expanded rapidly from <25% cover initially to >50% cover after a decade, which is critical to the success of the applied nucleation approach. Finally, although applied nucleation is cheaper than plantation-style planting and better simulates the spatial heterogeneity of natural forest recovery, there are some logistical and social challenges to overcome.

036.02 - Topsoil translocation for tropical dry forest restoration: resprouting of root fragments and germination of pioneers trigger forest regeneration

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Topsoil translocation has been effective for plant communities restoration, but this method had not been used for tropical dry forest restoration. We tested different methods of topsoil deposition for restoring a dry forest on an abandoned limestone quarry. The study was conducted in Federal District of Brazil. A 2.1-ha area was cleared of vegetation, and the topsoil from that site was deposited on an exotic pasture. The secondary forest was clear-cut, and the first 30 cm of topsoil were removed and translocated. Soil was transported in dump trucks to the deposition site, which had been scarified in advance, and deposited by either forming 1.25-m-tall mounds or by leveling the soil into a 40-cm or 20-cm deep layer using a hydraulic excavator. Seed bank and the availability of root and stem fragments in the soil were both surveyed. Origin of regenerants was categorized as either from seed or resprouting. We estimated plant cover for each life form, and measured trees and lianas. After six months, 74% of tree individuals and 60% of liana came from resprouting plant fragments. Ruderal herbaceous/shrubby species germinated from seeds. After 28 months, there were 51 species of trees, 8 lianas, 12 shrubs, and 34 herbs in the deposition treatments. The three deposition treatments were thickly covered with herbaceous/shrubby, and had nine times more species (44 vs. 5) and five times more tree density (1.17 ind./m² vs. 0.25 ind./m²) as than non-deposition control. Topsoil translocation was effective in kick-starting the recovery process of a tropical dry forest.

036.03 - Brazilian subtropical rainforest restoration: Comparing passive, applied nucleation and high diversity plantation approaches

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Brazilian restoration projects in subtropics regions where frosts are common are still not well documented. We compared three restoration treatments: 1) passive; 2) nucleation (set of techniques applied just in 1/3 of the area: artificial perches and shelters for animals; seed bank and rain seedlings planted in islets; cover crop, bromeliads and 36 trees spp. islets); 3) plantation using filling (10 spp.) and diversity (60 spp.) tree species planted in lines. Treatments were implanted in 54x40 m plots (four replications in randomized blocks) totaling 1 ha/treatment. The study area (Dois Vizinhos-PR) was used for decades for pasture and annual crops, before the clear cutting to begin this work. Vegetation, fauna, soil and costs have been monitored. In a 3-y old comparison between treatments, plantation presented highest canopy cover; but the highest understory cover founded in nucleation was probably responsible by its highest bird's activity and diversity. We found 17 birds' exclusive species to treatments (plantation showed bigger and more frugivorous species). Soil attributes and mesofauna didn't vary, but litter mesofauna H' diversity was bigger in treatments than in a reference area. Collembola composition was also different between treatments. Nucleation presented an intermediate level between passive and plantation methods, considering inputs, costs (34% cheaper) and dissimilarity with natural processes; but also in recovery speed, predictability and resistance to biological invasions. We recommend an integrated approach (islands of nucleation inside a plantation or vice versa) to increase the likelihood of developing the composition and diversity trajectory most widely desired in tropical forest restoration efforts.

036.04 - Subtropical Mixed Rainforest restoration: Are nucleation techniques sufficient to promote recovery of plant biodiversity?

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Different approaches have been used in tropical and subtropical forest restoration; most of them aiming at recovering the whole plant assemblages by tree seedling plantations. These approaches have given too much focus on tree species, and other forest plant life forms have been traditionally neglected. Nucleation techniques have been proposed as an alternative for assembling more heterogeneous communities, privileging a higher number of life forms, although still not sufficiently tested experimentally. We compared a set of nucleation techniques (T1) with passive restoration (T2) and conventional high-diversity (70 species) tree seedling plantation (T3), to test the hypothesis that nucleation promotes a higher species and life forms diversity of regenerating plants than conventional techniques. Nucleation techniques were: artificial perches and shelters for animals; islets of seed bank and seed rain seedlings; cover crop, bromeliads and trees (36 spp.) islets. The experiment (randomized block design with three treatments and four replicates) was installed six years ago, in Dois Vizinhos, southwest Paraná State, Brazil. Passive restoration and plantation showed similar results regarding native species density (all individuals with height ≥ 50 cm), while nucleation had about half the density of the others. Invasive grass cover was higher in T1 and T2, probably due to the longer time for canopy closure in nucleation and passive restoration plots. Nuclei did not seem to be large enough to promote grass suppression and native plant regeneration. We suggest a combination of techniques, including nucleation and plantation, to promote biodiversity recovery, potentially with lower implantation cost than conventional plantings.

036.05 - Distinction of the structure and floristic composition of an area in forest restoration process and another in natural regeneration

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In general, forest restoration actions are applied in degraded sites to initiate/accelerate the ecosystem recovery, but it's not always possible to compare the interventions results with a secondary succession. Here we made this comparison, as we distinguished the floristic and structural parameters of two different sites in a forest dominated landscape at Canela (southern Brazil): one undergoing restoration by the total planting seedlings method (PM) and one under natural regeneration (NR) process. Both were former *Eucalyptus* sp. stands that were harvested 8 years before the study. Twenty 100m² plots were allocated in both areas, where all individuals with Diameter at Breast Height (DBH) ≥ 4.8 cm were measured for height and DBH. For the regenerative stratum, two 4m² sub-plots were allocated in each plot, within which all individuals with height > 0.3 m and DBH < 4.79 cm were measured. All specimens were classified according to their successional categories and dispersion syndrome. The phytosociological parameters, species richness, diversity and similarity's indexes were calculated. For comparison, we used rarefaction curves, t-tests and Generalized Linear Models. Generally, data showed no significant differences between sites. In tree stratum the differences were basically in: height ($>PM$), secondary ($>PM$) and climax species proportion ($>NR$), zoochoric ($>NR$) and anemochoric species proportions ($>PM$). In regenerative stratum differences were in species richness and density ($>PM$). Even so, in this context, natural regeneration were sufficient to initiate the restoration of forest structure and ecological process. Therefore, a correct initial diagnosis becomes essential to choose the best restoration method, which may decrease restoration costs, turning it more attractive.

036.06 - Study of the successional state of a degraded area in the Cerro Corá National Park (PNCC), Department of Amambay

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Ecological succession corresponds to the temporal changes that occur in the structure, composition and functions of an ecosystem after suffering a disturbance. These changes and the speed at which they occur depend on the nature of the disturbance and the system's own properties (resilience and resistance) that allow it to reach the previous state or a different one from the original. The PNCC (5,538 ha) is located within the National System of Protected Wild Areas of Paraguay. The area had been used for many years as a military airstrip and the lack of information impedes management decision making to assist the process of natural regeneration initiated in the area. Four sampling units of 400 sq. m were established, all the species present were identified, soil samples were taken, key informants were interviewed. The overall objective was to determine the successional state of the degraded area, including the description of its history of use and management. The species and ecological group to which they belong were identified; the characteristics of the soil were described, and the barriers to succession were identified. As a result it was obtained that the area shows problems of infiltration, compaction and low content of organic matter; organic matter, all abiotic limitations that slow down the process of secondary succession. Ten herbaceous species were found. The system was evaluated according to the theory of processes that determine the substitution of species in succession of Connell & Slayter (1977) and the factors that influence the substitution of species.

S37 Improving governance to achieve more effective forest and landscape restoration

Organizer: James G. Hallett

S37.01 - Initiative 20x20 a country-led platform to restore 20 million hectares of degraded land in Latin America

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Initiative 20x20 is a country-led effort to bring under a restoration process 20 million hectares of degraded land in Latin America and the Caribbean (LAC) by 2020. Today, Initiative 20x20 has 49.7 million hectares of restoration pledges from 14 countries, and three regional programs. The objective of the Initiative is to change the dynamics of the land degradation process in LAC. The initiative has three main activities: a) a political dialogue to strengthen policies and address barriers faced by land restoration in the region; b) a technical effort in support of national restoration goals and c) an effort to bring private investment into restoration to complement scarce public resources. This effort is in support of the Bonn Challenge and the UNFF New York Declaration. Restoration strategies have been defined by the participating nations and include landscape management systems (agroforestry/silvopasture), natural and assisted reforestation and low carbon sustainable agriculture. The initiative also focuses in avoiding degradation. The initiative has developed a financial architecture to bring-in private sector investment and has an ambitious analytical effort in support of restoration goals. The presentation will focus on how policies can be put in place to both move the initiative forward and engage investors and stakeholders. It will also provide a summary of lessons learned so far and outline plans for the immediate future. Keywords: Landscape restoration, reforestation, avoided degradation, agroforestry, silvo-pasture, carbon sinks, economics, finance, governance, degraded land.

S37.02 - The challenges of opportunities: Scaling up national capacity for forest and landscape restoration

JAMES G. HALLET; STEVE EDWARDS; CATALINA SANTAMARIA; BLAISE BODIN

National commitments made under the Bonn Challenge and other related efforts signal the importance of large-scale ecological restoration efforts. Moving from commitment to action, however, will undoubtedly face challenges because of the need for new regulatory mechanisms and policies to support implementation and ensure equitable outcomes from restoration. These policies should encourage forest restoration planning that integrates restoration activities within the spectrum of forested and non-forested ecosystems across the landscape, current and potential land uses, and underlying societal interests. In this paper, we examine some of the governance issues involved drawing from the “Forum on Biodiversity and Global Forest Restoration” and other sources. We will start by considering how regulations might, for example, mandate restoration or provide incentives for public and private investment at the national level. Regional or sub-national efforts may require both enabling legislation and coordination at different levels of government. Government agencies responsible for land-use decisions may need to adopt policies that allow them to conduct restoration activities that accommodate non-forest biodiversity requirements, and ensure communication and coordination with other relevant agencies. Addressing such issues will take time, as will development of capacity for implementation and adaptive management. Consequently, mechanisms for both implementation and assessment monitoring will need to be established. Several international efforts are underway to develop both capacity for restoration and frameworks for monitoring. Ultimately, however, for restoration efforts to be successful, the views and needs of stakeholders must be considered and the benefits must be equitably distributed.

S37.03 - Exploring Social Factors that Influence Ecological Restoration

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"Humans are an integral part of every ecosystem on the planet. In the context of restoration planning and actions, personal interests and commitments often transcend legal authority. Human interests – and associated commitments – are highly stratified and may involve local, provincial, national, and global stakeholders, with each tier wielding varying degrees of influence over decision-making and ultimately the actions taken. One consequence of this ever-widening circle of stakeholders, often with widely varying and conflicting views of how an ecosystem should be managed or restored, is management is much more complicated. Simply put, to undertake a restoration project today is as much about how the social component is addressed as it is about the ecological science relevant to the restoration goals.

In this session, the "wickedness" of social and ecological problems affect planning and executing restorations will be reviewed; how conceptual frameworks that have broad acceptance in the international conservation community, can provide a means for goal setting, planning and managing restorations that span broad spectrums of stakeholder interests; and, how we can assess the risk that an ecosystem is vulnerable to collapse to provide an authoritative basis for pursuing a restoration project.

Participants' experiences will be sought to help contextualize the relevance of the various tools presented and how they might assist planning and execution of restoration projects."

038 Seeds and seedling production

038.01 - A new vision of seed transfer: Synthesizing the science of seed movement in a rapidly changing world

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Seed transfer guidelines are tools that help ensure that seed used in reforestation and restoration is “genetically appropriate” – adapted to local environmental conditions and reproductively compatible with remnant local populations. These tools have been used to guide reforestation practice for nearly a century in forestry, and have recently been adopted for use in the restoration and conservation of non-forest ecosystems around the world. In the last 15 years seed transfer guidelines have been constructed for a number of restoration workhorse species in the Great Basin of the western United States. One of the primary goals of the Great Basin Native Plant Project, a partnership between United States Forest Service, Bureau of Land Management and over 25 other cooperating groups, is to continue producing seed transfer guidelines for Great Basin restoration species. This talk will give an overview of what we can learn from seed transfer development and use in the Great Basin, show a novel statistical technique to better understand uncertainty in seed transfer guidelines, describe the development of a region-wide common garden network to swiftly develop seed transfer guidelines, and present a vision for the future of seed transfer in a rapidly changing world.

038.02 - Ecological restoration and native plant nurseries: An alarming mismatch on the way

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Active restoration of tropical forests is the predominant recommendation within human-modified landscapes, putting native plant nurseries as a central piece of the restoration supply chain. While Brazil is committed to fulfill international restoration goals and to enforce a recently revised environmental legislation (i.e. New Forest Code), native plant nurseries must be prepared to represent and replicate the remaining biodiversity. This study aims to expose an updated status of native plant nurseries in the state of São Paulo, Brazil. We discuss the factors affecting these activities and estimate the possible influences on production capacity (abundance and species richness) and job-related issues. From 340 plant nurseries listed on official assessments (2003, 2011, 2015), we sampled 179 (52.6%) and we will further investigate the remaining ones. From our sample, 123 (68.7%) are active, 48 (26.8%) are deactivated and 8 (4.5%) are reselling planting stocks from other nurseries. Considering the 56 (31.3%) nurseries that are no longer producing native species, we estimate a reduction of over 5 million seedlings and near 500 jobs. This shrinking market might also have a negative effect on overall diversity, since there are at least 546 native tree species available and most of the nurseries (81%) collect seeds from surrounding landscapes, an essential procedure to properly represent regional floristic composition and diversity. Amongst reported difficulties, we emphasize the effects of a competitive and non-organized market (undervalued prices), the lack of effective public policies and technical assistance, the implementation of the New Forest Code and the current national economic crisis.

038.03 - What fraction of seeds can we harvest from wild populations? Insight from a global data base of plant demography.

ANNA LAMPEI BUCHAROVA; ROBERTO SALGUERO-GOMEZ; J.F.SCHEEPENS; OLIVER BOSSDORF

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The growing number of restoration projects worldwide leads to increasing demand for seeds of native plant species. These seeds are often collected from wild populations that thereby suffer increased risk of decreasing population size and eventually extinction. To minimize this risk, seed collection guidelines usually indicate a maximum proportion of seeds to be harvested. However, the limits given in these guidelines are currently very inconsistent between organizations, countries and continents, and they are mostly based on expert opinions and rarely supported by empirical data. Here, we tested the effects of seed harvesting on population dynamics in 280 species from a wide taxonomic range and of various growth forms. We used empirical data from the COMPADRE database of plant population matrices to simulate seed harvesting (as a reduction in the part of the matrix describing seed production) and calculate, for each of the 280 species, the sensitivities of population sizes and population growth rates to this seed harvesting. Furthermore, we analyzed life history traits of the studied species for their potential to predict species sensitivities to seed harvesting. Plant longevity and seed bank survival negatively correlated with sensitivity to seed harvesting. Based on these two traits, we divided species into nine categories, and we determined the maximum proportion of seeds that may be harvested from wild populations of species in each category without significantly affecting population dynamics.

038.04 - Improving success of seed reintroductions.

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Recent reviews of rare plant reintroduction success indicate that far fewer studies have been conducted with seeds than whole plants and of these less than 10% have established or had long-term population persistence reported. Because seed reintroductions are relatively less expensive than plant reintroductions, determining ways to increase efficacy of using seeds to establish rare populations has conservation benefit. In laboratory trials we examined germination of seeds of an endangered legume, endemic of South Florida, U.S.A, *Dalea carthagenensis* var. *floridana* exposed to eight treatments. These confirmed that seeds are hard seeded, remaining viable for 1452 days even when moist; nicking, heat, and freezing triggered higher and more rapid germination than controls and no treatments were lethal. Field trials begun in 2009, using pre-treated (frozen) and untreated seeds within two habitats revealed that freezing pre-treatment increased germination in both habitats. However plants matured, reproduced, and established seedlings only in natural habitat, not in novel habitat. By 2012, treatment plots in pine rockland had significantly greater numbers of reproductive plants and seedlings than controls. In a restoration context, using seed pre-treatments to stimulate germination can improve establishment success in suitable habitats. When paired with vegetation management and a controlled burn, seed augmentation helped rescue the population from the brink of extinction.

038.05 - Seed systems for restoration: Baseline assessments of seven Latin-American countries

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Initiative 20x20 is a Latin-American country-led strategic alliance between (1) public authorities setting bold restoration goals, (2) impact investors committed to mobilizing financial resources; and (3) a wide range of national and international institutions providing technical and scientific support. The initiative has gathered commitments from 11 countries, 3 states in Brazil and three regional programs, bringing the total area to be restored to 27.7 million hectares. Among the priority areas of technical and scientific support identified by the country partners is the development and implementation of seed production and supply systems that are able to cope with growing demands (quantity) for planting material for restoration, while ensuring seed quality and pursuing financial sustainability through market-based approaches. We carried out baseline assessments of the current state of seed systems for restoration in seven Latin-American countries, by means of extensive expert interviews, an online survey, and screening of secondary information sources. We organized the assessments along the following components, consid-

ered essential for functional seed systems: 1. Selection and innovation (species and seed selection, breeding), 2. Seed production and multiplication (Harvesting from in situ sources, specialized seed production, nurseries, etc.) 3. Market access, demand and supply (Demand side, type of seed supply chains), 4. Quality control (seed sources registration and certification systems, best practices seed collection). Based on our findings, we developed a traffic light system to allow assessing and comparing overall seed system performance at the national level, providing opportunities for horizontal learning and identifying priority areas requiring more attention.

038.06 - Native seed preserves as a tool for diversifying tropical ecosystem restoration in México: a case study in the Central Gulf of Mexico region

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Mexican official efforts in reforestation are monumental, as Mexico is one of the top investors in forest recuperation worldwide, but there is strong concern regarding tree production for tropical forest restoration, since it is oriented towards a few species, ignoring the local tree diversity. In this work, we developed a seed-based strategy for increasing tree diversity in Mexican reforestation projects. First, we assessed local tree production capabilities in official forest tree nurseries of Veracruz state. Second, we developed a native-seed preserve aimed at promoting diversified seed management and distribution towards strategic regions based on relevant, native and locally appreciated tree species. We found that 15,894,800 tree were produced during 2014-2015 cycle, of which 67.36% of the production is concentrated in only five species of the genus *Pinus* whose optimal altitudinal range corresponds to less than 40% of Veracruz area. These results were used to design and promote both a local network of tree nurseries and a native seed preserve. The assessment was complemented with an evaluation of local appreciation of tree species based on actual and potential use. The former actions allowed to define quantitative goals for diversifying tree production on a seed management basis. We present quantitative and strategic information about native seed management (collection, quality, distribution) and forest nursery strengthening in Veracruz state as an alternative for species diversification in reforestation and restoration projects. Our results show capacity building and networking are keys for implementing large-scale initiatives regarding native seed conservation and forest restoration.

S39 Disturbed Tropical Forests: an urgent need for restoration

Organizers: Julia Raquel de Sá Abílio Mangueira and Ricardo Ribeiro Rodrigues

S39.01 - Beyond reforestation on cleared land: Why should we focus in a combination of restoration options including rehabilitation of degraded and secondary forests?

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Human-modified landscapes are ubiquitous across the tropics, with large tracts of forest being converted or exposed to fire, illegal logging and fragmentation each year. The Brazilian Amazon is no exception with forest degradation posing an ever-increasing threat to the ecological integrity of the entire biome. Despite the growing threat of disturbances, restoration policies have been mostly focused on reforestation on deforested land. Maintaining and restoring critical ecosystem processes and ensuring the persistence of native biodiversity will require a combination of habitat protection and restoration but also rehabilitation of forests in varying stages of degradation. We will present results from the Sustainable Amazon Network (RAS), a multi-landscape assessment of land-use sustainability in the Eastern Brazilian Amazon. Extensive survey data on plant and faunal groups were linked to remote sensing data to model biodiversity patterns as well as estimates of carbon stocks across a range of forest conditions. We explore trade-offs between protecting relatively undisturbed primary forest, avoiding degradation and restoring degraded primary forest, and protection of secondary forests. Species distribution maps were used to explore trade-offs among management actions and to identify priority areas for habitat protection, rehabilitation and restoration, using the software Zonation. We find that where restoration imposes significant opportunity and implementation costs, to avoid and reverse degradation of standing forests can deliver greater returns on investment for biodiversity conservation. Systemic planning of management options at regional scales can substantially improve expected biodiversity outcomes while minimizing costs, and provide valuable information for decision makers in this biologically unique region.

S39.02 - Restoration of Forest Remnants: State of art and research gaps in Brazil

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In most tropical regions, the little forest cover that has left is mainly composed by secondary forests and primary forests experiencing arrested succession. Despite their degradation status, these forests represent the last refuges for biodiversity, and therefore should be subject to forest management, which should focus on strategies to increase their role for biodiversity conservation. Thus far, restoration ecology has focused on testing strategies to recover open and highly degraded areas, but considering that forest restoration is now a global priority, this is a great opportunity to include different strategies to increase success in large scale restoration programs. In Brazilian Atlantic forest, for the past few years, several studies have tested different strategies to manage forest remnants. Where active restoration was necessary, the introduction of individuals to increase density or species richness, management of hyper abundant vines, and management of exotic invasive species were tested. We argue that only with an accurate assessment it is possible to identify the main issues to be addressed, and that the adaptive management approach should be used for forest restoration. Based on data accumulated so far, degraded forest restoration is possible, since few issues are observed: proper administration of restoration projects, since it is very likely that repeated actions are necessary until full community recovery; use of local and regional resilience; and adaptive management, considering that the degradation factors that harm forest fragments will continue to operate in human-modified landscapes.

S39.03 - Enrichment planting strategies to restore degraded tropical remnants

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In tropical areas with high levels of fragmentation due to agricultural use, forest fragments play an important role for biodiversity conservation at the landscape scale. But these fragments are subject to recurrent disturbances, such as fire and overabundance of vines, which lead to arrested succession and loss of functional groups. Therefore adaptive management could facilitate recovery. Although many authors have suggested enrichment planting in remnant forest as a conservation strategy, few studies have tested specific techniques. Among forest management studies, forest enrichment has been tested as a strategy for enhancing the biodiversity of restoration plantings or to increase the economic value of secondary forests, by introducing valuable species, but few have tested for biodiversity conservation purposes. In Brazilian Atlantic Forest, we performed an experiment with four late secondary tree species as seeds, small seedlings, and large seedlings in three remnants embedded in a landscape dominated by sugarcane plantations, and we evaluated the costs to implement them in the field. Direct seeding is the least expensive technique but was successful only for one large-seeded species. Survival was greater for large than small seedlings for all species, suggesting that the additional cost of large seedlings is warranted to enhance success. Our results highlight and experiments in other tropical regions support that forest enrichment is highly contingent on weather conditions, especially rainfall availability, and that management strategies should be selected at the species level to increase restoration success.

S39.04 - Restoration of disturbed forests in protected areas: experiences in Southeastern Brazil

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Degraded tropical forests, despite their lower biodiversity and biomass, are important for biodiversity conservation and human wellbeing in fragmented landscapes. Many tropical regions have degraded forests, which should be in the agenda of forest restoration programs, and one of the main issues for their restoration is the management of abundant climbing plants. To address the lack of large-scale initiatives aiming to validate the practice of restoring degraded tropical forests, we established, in 2013, a long-term project in the Vassununga State Park, a protected area in the Atlantic Forest of Southeastern Brazil. The park experienced a strong fire in the 1970's and forests are in a steady state of degradation. Private companies, environmental bodies and researchers are involved. We installed 10.6 ha of permanent plots to investigate costs, operational feasibility and effectiveness of liana cutting, assisted natural regeneration and enrichment plantings as techniques for restoring degraded forests. We found that the composition of lianas is different from that of less degraded landscapes, and the restoration strategies should consider the fast and multiple resprouting of most climbing plants after cutting. More data will be generated in the following years. Once these techniques are validated, the next step is to convince that managing degraded forests in protected areas may be more cost-effective than traditional tree plantings in cleared sites. Additionally, it is necessary to develop policies to foster degraded forest restoration. Ecological restoration is now a global priority and it is an opportune time for new approaches in its science and practice.

S39.05 - Restoration of forest fragments as a strategy to accomplish global and regional restoration goals.

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Brazil has international commitments (Bonn Challenge, 20X20 Initiative, Paris Declaration) and regional (Native Vegetation Protection Law) signed for the fulfillment of restoration goals in the Atlantic Forest (AF) area. In order to deliver these goals, it is necessary to include human modified landscapes in AF that are predominantly composed of small forests fragments. These landscapes are responsible for retaining much of the threatened biodiversity of this ecosystem and providing environmental services that are fundamental to society. Then, a summary will be presented of how restoration initiatives in these landscapes are contributing effectively to the implementation of the goals established in this commitment.

S41 Restoration of ecosystems in the tropical Andes: lessons from research and practice in highly heterogeneous landscapes

Organizer: Manuel Peralvo

S41.01 - Successional vegetation dynamics in old-fields across the tropical mountain treeline: from patterns to mechanisms

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In the high tropical Andes, the mountain treeline corresponds to a complex transition zone between high Andean forests and páramos. Understanding the dynamics of this ecotone has become a high priority in the region given the increasing pressure derived from the combined effects of agriculture, cattle grazing, and global climate change. However, even though the mechanisms driving treeline dynamics in temperate areas have received considerable attention, these processes remain largely unexplored in tropical mountain regions. Here, we review the available research in the Venezuelan Andes on vegetation dynamics in natural and disturbed areas across the treeline. Results from this research point to similar barriers limiting the establishment of woody plants both in old-fields within the forest matrix at the upper forest line as well as in natural open areas above the treeline. Among the factors that seem to act as a barrier for forest regeneration or altitudinal advance are the high radiation levels characteristic of high tropical mountains as well as limitations in water and nutrient availability, particularly within old-fields. Moreover, our research indicates that local plant-plant interactions, especially facilitation by shrubs, play a key role in the colonization dynamics of trees. On the basis of the available evidence, we discuss the need for the establishment of continental-scale initiatives for diachronic monitoring of vegetation dynamics across the tropical treeline and for the design of restoration strategies adapted to the ecological context and drivers' characteristic of the highland tropics.

S41.02 - Restoration trials in the Andean forests of the Pichincha Province, Ecuador.

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Considering that a large number of areas worldwide have already lost their productive capacity, both ecosystemic and agricultural, and that resources destined for restoration are often limited, it becomes crucial to identify successful ground-based adaptive restoration strategies which can simultaneously help with conservation efforts as well as provide families with a sustainable production alternative. We established six experimental sites in degraded and/or intervened areas considered of local priority for conservation in the Andean Choco Bioregion in Ecuador. Study sites were located in three forest types (foothills, lower montane and montane) and considered different designs and objectives. The planning process and establishment of these areas followed a six-step methodological order, specifically, designs were generated and applied using native species and different means of propagation. A "Protocol for Monitoring Ecological Restoration Areas in the Andean Choco Bioregion of Ecuador" was developed and used for this purpose, detailing the application of 10 ecological and two economic indicators. Preliminary results of this ongoing monitoring process show that vegetative reproduction of suckering plants has presented a rapid coverage of soil; the primary productivity indicator proved to be useful to demonstrate changes in the restoration process (an average increment of 82% in 6 months in areas which contain fast growing species, that accumulate 0,19 to 0,30 kg/ha of biomass). Additionally, we present lessons learned from these experiences, showing that restoration practices become feasible when they include sustainable production as an objective.

S41.03 - Assessment of Ecuador's national restoration program areas in northwestern Ecuador

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In the last decade, there have been an increase of initiatives that seek the restoration of forest landscapes at a large scale; nevertheless, there are still gaps in information regarding to the results or impacts of these initiatives. Hence, due to the huge economic investment involved in these efforts, it is important to assess the effectiveness and impacts of these initiatives. The purpose of this research was to assess the ecological impact, mainly from biodiversity and carbon storage measurements, in areas in an ongoing restoration process that were part of the national program of forest restoration in Ecuador, implemented by the Ecuadorian Government through the Ministry of Environment. Also, we want to validate the sensibility of 11 indicators to measure the impact of these restoration strategies. We focused in four parishes of Pichincha province (Nanegalito, Nanegal, Gualea, Mindo). We installed plots in the 24% (310,6 hectares) of the total area intervened with restoration activities within the four parishes. A total of 29 plots and 35 transects (the type of sample unit, plot or transect, depended on the restoration strategy) were installed and the baseline information was collected; during this year 2017 we will conduct two additional measurements of the indicators, at 6 months and 12 months. Here, we present the preliminary results derived from the baseline and first census that allow us to make a first assessment of the impact of the national program of forest restoration; we analyze the opportunities and limitations of this national initiative.

S41.04 - Identification and prioritization of forest restoration areas in a mountain watershed in the Ecuadorian Andes at two spatial scales.

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The need to prioritize areas for ecosystem restoration is well established as resources are generally scarce. In mountain landscapes with complex land use mosaics, this is critical as these areas present greater pressure over suitable land for agriculture and other human uses. We designed a spatial multicriteria methodology to select priority sites for ecosystem restoration in a highly biodiverse tropical mountain watershed in the Ecuadorian Andes. The study area covers approximately 35,000 ha of a highly-fragmented mosaic of montane forest in an altitudinal range between 400 and 1900 m.a.s.l. The prioritization was implemented at two spatial scales. At the watershed level, priority sites were identified using a land use suitability index and an ecological importance index. The land use suitability index was calculated using a machine learning technique known as maximum entropy modeling (Maxent) linking observed land use patterns and topographical and market accessibility variables. The ecological importance index was calculated using habitat fragmentation indices, including distance between patches of remnant forest. Both indices were combined using different relative weights to generate alternative priority scenarios. Within priority areas, five farms were selected and restoration plans were developed with the participation of land owners. The plans identify fine scale factors that promote the feasibility of different land management goals such as restoring riparian vegetation and excluding areas from grazing. The results suggest that the two-tiered prioritization approach optimizes the synergies between ecological goals and engagement of local stakeholders, and promotes the persistence of the restoration activities in the long term.

S41.05 - Evaluation of peatland restoration practices as a means for sustaining alpaca pastoralism in the Peruvian highlands

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Alpaca pastoralist populations in Huancavelica, Peru produce large amounts of wool and fiber. However, this region continues to be amongst the poorest in Peru. Overgrazing in this area has decreased the carrying capacity of the system, which may be problematic for continuing present levels of grazing. Therefore, a restoration system was installed by the Peruvian government

in collaboration with the Belgian Development Agency. Specifically, the restoration practices aimed to increase vegetation biomass and palatability, indicated through increased biodiversity, to benefit alpaca grazing. The effects of the restoration practices were evaluated using a block system that included a control, and a reference site. From each block, data on vegetation composition and structure, below and aboveground biomass, and soil organic matter were obtained. Vegetation surveys were used to obtain plant community composition and structure as well as dissimilarity distances between blocks. Effects of treatments on the response variables were analyzed using a linear mixed-effects model, setting treatments as fixed effects, sites as random effects, and time as a covariable. Results from the analysis suggest that exclusion may be affecting vegetation composition and abundance of species but not species richness. Conversely, belowground biomass and soil organic carbon did not show changes from the restoration treatments. Therefore, although some of the treatments were installed as late as 2013, we can already observe changes in vegetation composition and structure from the restoration; yet more time may be needed to detect changes in other variables, such as belowground biomass and soil organic carbon.

S41.06 - The potential contribution of local knowledge of woody plants to ecological restoration in Apurímac, Peru

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Ecological restoration interventions need to be finely adapted to local socio-ecological conditions. Such adaptation is especially challenging in the highly variable context of mountain areas. Drawing on a case study from Apurímac, in the Southern Peruvian Andes, I will show the depth of local knowledge about the ecological functions of woody plants, and discuss the potential and limitations of using it to inform restoration practice. The data come from three communities in a micro-watershed that covers a diversity of ecological zones and production systems. They were collected using a combination of participatory and ethnobotanical tools, including focus group discussions, field walks, and in-depth interviews with 38 farmers. Local ecological knowledge was documented and qualitatively analyzed using the Agroecological Knowledge Toolkit software (AKT5). Quantitative salience analysis was performed on the plant species listed during the interviews. The results showed that farmers have detailed knowledge on the ecological functions of shrubs and trees—in particular native species—for soil and water conservation, including erosion control, promotion of soil fertility, and soil conservation. This knowledge varies across the watershed, and reflects the heterogeneity of ecological and land use conditions. As such, it constitutes a valuable source of information to guide restoration practices, in particular in settings where fine-scale scientific data are not available.

S42 Big Ideas | Big Practice - Do Big Ideas Matter in Restoration?

Organizers: Paddy Woodworth and Justin Jonson

S42.01 - The power of words in ecological restoration: are we building a Tower of Babel?

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Words represent ideas. Miscommunication happens when two people use the same word but imagine different meanings, or use different words to mean the same thing. The potential for miscommunication increases with concept complexity. Ecological restoration, just like “Nature”, is a complex concept that elicits different meanings for different people. Furthermore, there are many definitions of the term ecological restoration, but most are vague, accommodating the myriad visions of stakeholders involved. The result is observable confusion among scientists, practitioners, decision makers, managers and stakeholders as to what ecological restoration actually is, and what it should accomplish. This confusion is compounded by the existence of related concepts such as recovery, rehabilitation, and reclamation that require conceptual refinement, but this often does not reach beyond the scientific community. For lay people these are all synonyms, and their use varies among countries or communities, and across languages, adding confusion. In Peru and Bolivia, for example, “restoration” is used on legal documents, sometimes as a synonym of “recovery”, but never in everyday language. Instead, people use the word “recovery”. Yet, for some actors, recovery produces more complex ecosystems than restoration, while others think the opposite. Confusion is compounded by additional terms such as novel, non-analog, designer or emerging ecosystems. Although this lack of linguistic alignment could be dismissed as semantics, evidence shows that a misalignment of project visions and expected outcomes can result in project failure. Most importantly, the misunderstanding and confusion contribute to the detriment of biodiversity and the discredit of our discipline.

S42.02 - Restoration in Mexico: The challenge of integrating society, ecology, politics and practice

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Mexico is one of the 17 megadiverse countries. However, in the last four decades, ecosystem degradation has seriously threatened this diversity in rural and urban areas. Meanwhile, approximately three million households, which manage 59% of Mexico’s land and 80% of forest areas, operate within community-based ownership systems. Indigenous communities, therefore, are one of the most important decision-making groups ecosystem management. Most of these social groups experience poverty (70%), injustice, violence and drug trafficking in their territory. So ecological restoration in Mexico takes place within a complex context that demands holistic, transdisciplinary approaches. Yet at the 1st Mexican Symposium on Ecological Restoration (2014), only 21% of presentations referenced social participation. And although Mexico has committed to restore 8.5 million ha within the 20x20 initiative, there is still no National Restoration Plan, nor any strong, coherent policies to implement ecological restoration. The epistemological, methodological, organizational and institutional changes needed to respond to these challenges must be urgently addressed by the public higher education system, where most restoration research is carried out. The universities must therefore transform themselves by thoroughly revising their curricula towards transdisciplinarity and forging strong working links with different sectors of society. Legal instruments to implement ecological restoration actions are also essential. Government, universities, the private sector and civil society must establish a “Mexican restoration pact”, similar to the Atlantic Forest Pact in Brazil, to bring health back to degraded lands and society. For this multi-dimensional project, restoration ecology must develop clear, accessible and flexible conceptual language.

S42.03 - Ideas of antiquity: old-growth savannas and misperceptions of tropical forest degradation

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Despite growing evidence of their irreplaceability and value to human livelihoods, ancient grassy biomes, including old-growth tropical savannas, are often misdiagnosed as “degraded” and targeted for “restoration” through tree planting and fire exclusion. To avoid afforestation and forest expansion in ecosystems with naturally low tree cover, restoration ecologists and policymakers must distinguish old-growth savannas from deforested land. Long periods of time are critical in the formation of old-growth savannas, but signs of their antiquity are not widely recognized. To survive frequent fires and large herbivores – forces that maintain savanna biodiversity – many savanna plants develop underground storage organs that enable them to resprout repeatedly. Hence, evidence of plant longevity and ecosystem carbon storage often reside below ground. At the community level, savanna antiquity is reflected in high species richness, high endemism, and unique species compositions. Old-growth savanna communities require centuries or longer to reassemble following intensive human land uses (e.g., plantation forestry, tillage agriculture) or altered disturbance regimes (e.g., fire exclusion). Toward better integration of tropical savannas in forest-focused restoration efforts, I developed a model that conceptualizes the drivers of human-induced environmental change as operating in both savannas and forests. This model highlights that tree cover alone cannot be used to identify ecosystem states, assess conservation values, or determine restoration need. To move beyond an over-reliance on tree cover, data from eastern lowland Bolivia demonstrates that basic floristic information (i.e., grass species identities) can be used to reliably distinguish old-growth savannas from deforested and degraded forest lands.

S42.04 - Finding Common Ground: Lessons learned about language and big ideas across 45 years of Earthwatch Institute global ecological restoration

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Restoring ecosystems and improving ecological resiliency in our rapidly changing world can best succeed by using a multi-disciplinary approach in which researchers, practitioners, communities, and volunteers find common ground through clear communication of ideas. When working in a region that includes Indigenous communities and a variety of stakeholders, including agricultural as well as urban communities, it often means working across cultural chasms, so that precise and sensitive use of language always plays an important role. I present the lessons learned and partnerships developed in restoring ecosystems worldwide in nearly five decades of citizen-science based research. The 1,400 research projects Earthwatch has supported over the years have clearly demonstrated which ecological restoration strategies work (e.g., embedding a project in the community), and which are less successful (e.g., external university researcher arriving, doing the work in a short timeframe and leaving). This experience highlights the value of 1) incorporating diversity on multiple levels (ecological, disciplinary, and cultural) in ecological restoration projects; and 2) scaling-up efforts temporally and spatially from the local to the global in order to produce enduring impacts. This sort of scaling-up necessitates investing in big transboundary ideas that have global applicability regardless of the culture. Effective communication, education, and co-creation of ecological restoration projects are all elements of successful projects. I discuss the common themes in communicating across cultures about large-scale conservation initiatives and engaging a spectrum of stakeholders, featuring case studies from the Amazon, Africa, and Mongolia and from corporate and public citizen science programs.

S42.05 - Closing a door and opening a window: The costs and benefits of standardization in restoration ecology

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As ecological restoration scientists work to construct clear definitions of key concepts in the discipline through avenues such as the Society for Ecological Restoration’s recently released “International Standards for the Practice of Ecological Restoration,” it is important for the restoration community to reflect on the tradeoffs between tight conceptual clarity and more open-ended

definitions. Two benefits of the former are that a shared lexicon can foster disciplinary expertise, and standardization of key concepts can help ensure consistent application among practitioners. However, standardization also has costs: Openness to multiple meanings is an important component of innovation, and is at the heart of disciplinary progress and socio-historical resilience. Furthermore, conceptual openness respects local autonomy and the contextual nature of meaning-making. Standardization then, should be moderated by a healthy respect for the benefits of conceptual openness. I aim to provide a framework for thinking about how and when to provide standardized definitions from above, and when to entertain purposeful openness. I also highlight the role of metaphors, meanings, and narratives and argue that to connect effectively to policies and publics, it is essential to avoid the reductionist path of overzealous terminological standardization. Ecological restoration has been filled with scientists and practitioners who make brave departures from typical discourses, and it should continue this tradition by blazing new trails that link science, policy, and practice in a way that strives for both scientific precision and adaptability to the larger sociocultural contexts in which meanings are constructed.

S43 Restoring wetlands for the future: prioritizing resilience to climate change in wetland restoration projects

Organizer: Julia Cherry

S43.01 - Wandering wetlands: Moving targets and restoration of wetlands under climate change

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Wetlands are naturally dynamic environments, experiencing changes in water flows, episodic flood events, species movements and so on. Wetlands are also at the front line of modification by human activities, with urban expansion, agricultural use, resource extraction and coastal development all influencing wetland structure, composition and function. In the face of on-going climate change, the rate and extent of modification of wetlands is likely to increase. In addition, wetland distributions and zonations are likely to change as, for instance, sea levels rise and storm events increase in frequency and severity. At the same time, the vital importance of wetlands in terms of the biodiversity they contain and the ecosystem services they provide is increasingly being recognized. How to manage and restore wetlands undergoing both episodic and directional change is an important conundrum for managers and policy makers. Setting appropriate goals for wetland management and restoration has to account for moving targets in terms of wetland composition and function and also moving wetlands as distributions change in response to human mediated changes. I explore a variety of approaches that are being considered in different parts of the world, including open-ended restoration, maintaining novel assemblages, and anticipatory management to facilitate migration.

S43.02 - Maintaining ecosystem services in restored coastal wetlands experiencing sea-level rise

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Restoration of degraded tidal wetlands can recover important ecosystem services while also promoting resilience to future climate change impacts, including sea-level rise (SLR). To evaluate the effectiveness and resilience of wetland restoration, we restored three marshes at Weeks Bay National Estuarine Research Reserve in Alabama, U.S.A. using different initial planting densities (0%, 25%, 50%, 75%, and 100%) of *Juncus roemerianus*, an ubiquitous estuarine plant, and examined plant community structure and ecosystem function (i.e., nutrient removal) under current and future SLR conditions. For this study, we used passive weirs that increased the depth and duration of flooding during low tide to simulate future SLR. After three growing seasons, plant percent cover was similar among the 50, 75, and 100% initial planting densities, regardless of SLR, although the relative abundance of flood-tolerant species tended to increase with SLR. Furthermore, dissolved inorganic nitrogen (DIN) concentrations in the sediment porewater were similar among the 50%, 75%, and 100% planting densities, and significantly lower than in the 0% and 25% treatments. Sea-level rise effects on porewater DIN concentrations were small in comparison with the effects of planting density. In sum, we found that similar restoration outcomes could be achieved at lower cost using the 50% initial planting density, regardless of SLR conditions. Our results show that ecosystem function can be preserved in restored marshes under rising sea level, and that initially planting at 50% offers the highest short-term return on investment.

S43.03 - Does Fire Promote Upslope Migration and Resiliency to Climate Change in Coastal Wetlands along the Northern Gulf of Mexico?

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Coastal plant communities along the Northern Gulf of Mexico coast are subject to chronic sea level rise (SLR) and increasingly intense tropical storms. Some species are resilient and cope by trapping inorganic sediment and accreting organic material. When rates of SLR exceed their capacity for vertical resilience, upslope migration is necessary for long-term persistence in the landscape. Upslope vegetation, often dominated by long-lived woody species, creates barriers to migration of herbaceous marsh species, leaving the latter highly vulnerable when they are squeezed at the seaward end of their distributions. We hypothesized that disturbance to upslope vegetation opens establishment opportunities and promotes landward establishment of marsh. In April 2015, we identified four pine island-marsh complexes at Grand Bay National Estuarine Research Reserve, Mississippi, USA; two were burned and two were unburned. In July 2015, we initiated a reciprocal community transplant experiment using replicate sods (containing propagule banks) excavated from four dominant vegetation types: salt marsh, brackish marsh, fresh marsh and pine savanna. Sods were reciprocally placed into each of the zones, including source zones for control of transplant effects. Preliminary results indicate successful upslope establishment and poor survival of downslope transplants for all assemblage types. Species richness in experimental plots was highest where assemblages were migrated upslope several zones and in burned areas. Long-term survival may be constrained by competitive interactions with species from surrounding vegetation, particularly re-sprouting shrubs. Thus, repeated burns may be necessary to promote survival and expansion of upslope migrants.

S43.04 - Restoration of estuarine function to Lake St Lucia: Lessons learned, implementation and monitoring for this highly significant estuary within South Africa's first World Heritage Site.

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Lake St Lucia is South Africa's largest estuary, and arguably its most important, as it comprises 60% of the total estuarine area of the country. Its diversity and uniqueness make it the core, or heart, of the iSimangaliso Wetland Park, South Africa's first UNESCO World Heritage Site. Historically, a single intervention to address perceived risks to sugar-cane farming and the estuary in 1952 initiated a long-term decline in ecological health. This single action prompted a cascade of subsequent interventions which failed to address the key issues driving estuary degradation. This general decline reached crisis levels with the loss of estuarine function and the concomitant declines in marine resources beginning in 2005 and escalating over the next decade. The state of this important estuary prompted a major reassessment of management approaches and this led to the development of a restoration framework which was investigated and implemented from 2010 through to 2017. The previous paper at SER 2013 set out the history and philosophies underpinning the case for restoration, described the results of a multi-disciplinary study and proposed the major engineering actions to restore the estuary. This paper will provide an update of the key engineering intervention chosen to unlock restoration potential, the challenges faced when rolling out the restoration plan from paper to performance and the monitoring techniques which will track system health.

S43.05 - Community based ecological restoration of peatland in Central Mongolia for climate change mitigation and adaptation

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Peatlands cover around 1,5 % of Mongolia and play a crucial role in the regulation of key natural processes maintenance of traditional way of life and livelihoods of herders. During the last decades, Mongolian peatlands have severely degraded both due to the climate related events and overgrazing. This causes losses of carbon store, increases GHG emissions and is followed by permafrost thaw and changes in the hydrology. The issue arises if peatlands could be a subject for ecosystem restoration in this arid and subhumid climate. With funding from the Asian Development Bank a pilot project for peatland restoration had been launched in 2016 in Central Mongolia. The pilot aimed to merge local interests of herders with global targets of climate change

mitigation. The issues addressed: the losses of natural functions and ecosystem services of peatlands; expectations and demands of local communities and incentives for their involvement; the target ecosystem characteristics; the technical solutions; and parameters for monitoring to assess the success of the project. Restoration in subhumid conditions should avoid creation of open water surfaces: channels, reservoirs, and focus integrative ecosystem management. The restoration concept involved fencing of springs, preventing erosion and water accumulation in soil by cascades of small dams and other small scale ecological solutions. In order to meet the needs of local herders and keep animals from springs, the dam, constructed by herders had been repaired, even if it has little value for peatland restoration. The success evaluation included both natural and social aspects.

044 Community engagement in ecological restoration: cultural and philosophical aspects

044.01 - Navigating the social in restoration projects: Challenges, strategies and ethical quandaries

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Restoration literature indicates that an exclusive ecological focus in restoration efforts diminishes chances of success. Including the social dimension is increasingly recognised as important in achieving a project's sustainability. This paper warns against a naive approach to social systems: their complexity and inherent power dynamics demands insight and carefulness. A key question must be 'How can potentially destructive human systems be accommodated in ecological restoration projects?' This is particularly important in a globalized, modern context where many cultural practices, seemingly adapted to local ecosystems, have been eroded. This raises the possibility of focusing attention on the human aspects of social-ecological systems that might also need to be 'restored'. Various authors have argued that both cultural and ecological processes be included in restoration to enhance co-evolution of people and nature. There are ethical challenges related to such thinking in the context of practical restoration projects. In recognising the very real inequalities of power currently experienced in ecological restoration projects in terms of knowledge and the primacy of western science and technology, such an approach requires careful thought and deep discussion, as will be discussed in this paper. Two community focussed restoration projects from the Eastern Cape Province of South Africa will be evaluated through the lens of cultural ecological restoration to better understand the tensions within an integrated, but degraded social-ecological system.

044.02 - Restoring and reviving cultural forests in southern Brazil: A biocultural approach at Ibirama-Laklãnõ Indigenous Territory

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Restoration of forest ecosystems in southern Mata Atlântica, particularly the iconic Araucaria Forests, central to the identity and livelihoods of indigenous and non-indigenous people in the region, require integrative approaches that consider both biological and cultural dimensions in a context of socioecological transformations and adaptations. Despite growing evidence of ancestral human influence in the expansion and maintenance of such forests by indigenous management of fire and dispersal of staple araucaria-pine nuts (seeds) (*Araucaria angustifolia*), forest remnants are mostly concentrated in protected areas and private land, not within present territories of the Kaingáng and Laklãnõ-Xokleng Indigenous Peoples of southern Brazil due to processes of displacement and deforestation. During the last few years, we carried an interdisciplinary study on ecological history, indigenous perceptions of change and forest biodiversity at Ibirama-Laklãnõ Indigenous Territory, in order to understand the impacts of human action in a region of transitional forests (*Araucaria* and Dense Atlantic) and identify indigenous strategies and adaptations for conservation and restoration of local ecosystems in the last century. The Laklãnõ-Xokleng have been through different cycles of change and adaptation, the last being mostly focused on cultural rekindling and ecological restoration after decades of illegal overexploitation of their forest resources. Restoration of forests for the Laklãnõ-Xokleng has been a process of bringing life back to these ecosystems, including transmission of traditional ecological knowledge, oral history and traditional practices of forest management. Biocultural approaches that guide Laklãnõ-Xokleng ethics and practices can be of great value to restoration endeavours within the region inside/outside indigenous territories.

044.03 - Integral Ecological Restoration: Restoring the Link between Human Culture and Nature

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Restoration Ecology has progressed significantly and there are several techniques available at different costs, which allow the science (restoration ecology) to be put into practice (ecological restoration) and scale up across different ecosystems. However, effective restoration depends on people having real engagement, empowerment, and development. Integral Ecological Restoration is a social process that aims to integrate human well-being, environmental health, and spirituality, the non tangible relation between human and nature. Its goal is to restore or install the link between human culture and nature, considering that each individual and community have their relation with nature “degraded” at different extent. Integral Ecological Restoration starts at the individual scale in the mental environment, and can scale up to promote social and environmental revolutions worldwide. Education is the main key for that. Many people have no opportunity to identify their own gifts and wishes because of poor life conditions and the education system that teaches fragmented and reductionist knowledge. The early contact of the child with nature is decisive for their full development and to build the link with nature, but adults can also “wake-up” if provided with good opportunities. Education methods do exist and many people with different backgrounds work aligned with Integral Ecological Restoration. As scientists and human beings we must remind our most urgent assignment: take care of our Planet and our People, independent of ethnic origin, financial condition or religious belief. In this context, restoration is more than a scientific subject, it is a sublime mission.

044.04 - Eliding nature/culture dualism: An actant-network perspective on narratives of ecological restoration

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Scholars in the sciences and the humanities have recently called for increased attention and scrutiny of the ways in which language and narratives shape human understanding of nature and culture, and how these understandings in turn affect human actions and practices such as ecological restoration. Similarly, a number of academics and practitioners have called for new ways of telling stories about nature, culture and the environment. While various approaches to narrative have been advocated, most of these leave intact core patterns of Western thought, such a tendency to structure experience according to binary categories such as “nature” and “culture,” and a predilection for linear causality. This paper explores the perspective offered by Actant-Network Theory (ANT), an approach to analyzing and narrating accounts about humans and the environment that largely abandons these conventions. Actant-Network Theory stems largely from the work of historians and sociologists of science and technology. It is perhaps best characterized as a nested set of propositions that guide investigation of human-nature relations. Foremost of these is an ontological position that elides binary categories, and a proposition that entities in the world may be known only in terms of their relations to other entities, a premise that makes “network” an apt metaphor for conceptualizing chains of relations. As a result, ANT begins to offer an interpretive framework that may prove useful to ongoing efforts to tell new kinds of stories about ecological restoration—narratives that reveal insights and truths that may remain obscured by conventional perspectives.

044.05 - Ethical and social implications of Ecological Restoration in the Anthropocene: How to increase the capacity of the agency of local communities to protect, restore and promote the sustainable use of terrestrial ecosystems?

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This paper analyzes the ethical and social implications of ecological restoration in relation to local communities and their capacity to promote the sustainable use of terrestrial ecosystems. In the first part, a critical hermeneutical analysis of three cases of ecological restoration is offered in order to show the advantages of incorporating the communities into projects oriented to

protect and restore the environmental, instead of generating sanctions to superficially improve their social involvement. In the second part, we will bring into question the global public policies aimed at facing the overwhelming changes and uncertainties generated in the Anthropocene. If the Anthropocene can be conceived as a geological era in which the human footprint is generating deep and radical changes on the planet and the biosphere, then it is essential to generate public discussions capable of transcending traditional forms of governance towards new and better modes of global political action. If a strong involvement of local communities is present, then denying support for ecological restoration projects becomes less probable. The paper concludes by reflectively linking ecopolitics and new forms of global governance within the perspective of Arne Næss ' ecophilosophy, which can be used to link theory and praxis in the framework of ecological restoration as a way of attaining a better future.

045 Plant invasions: ecology and control

045.01 - Do restoration plantings increase the biotic resistance against exotic plant invasions?

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Exotic plant invasions often change ecosystem properties and drive the successional trajectories of invaded sites. There is evidence that more diverse sites show higher resistance to exotic plant invasions due to more abundant natural enemies, such as pathogens, herbivores and seed predators. Invasive exotic plants often colonize new sites through seed dispersal. If dispersed seeds survive then invasives can become established. Therefore, seed removal/predation can play a role in controlling the spread of invasive exotic plants. Since successful restoration projects should restore ecosystem functions we expect that sites ongoing restoration should have stronger biotic resistance to exotic plant invasions than disturbed, non-restored sites. We tested this idea in a gradient of Atlantic forest disturbance and recover in southeast Brazil. We mimicked the first stages of exotic plant invasions and compared the post-dispersal removal of seeds from three highly invasive exotic plants: Castorbean, *Ricinus communis*, Indian lilac, *Melia azedarach* and White leadtree, *Leucaena leucocephala*. Seed stations (n=270) were placed in transects crossing each of three Atlantic forest fragments, restoration plantings and abandoned pasturelands for two years. As expected we found higher overall mean seed removal in forest fragments (51%) followed by restoration plantings (43%) and pasturelands (37%). The effects were consistent between years. Toxic seeds (e.g. *Melia*) were more likely to survive (86% survival after 14 days) rather than seeds from more palatable species (66% for *Leucaena*, 18% for *Ricinus*). Restorations are partially recovering the resistance to plant invasions through enhance of negative interactions with propagules of invaders. However a large amount of seeds from exotics were able to survive the first weeks of invasions. Therefore restorations are more likely to control the abundance of invaders rather than stop invasions. Special attention should be paid to the risk of invasion by exotic invasive plants that have seeds with toxic compounds that deter native seed predators.

045.02 - Factors limiting forest regeneration in bracken-dominated areas in the tropical montane forest of Bolivia

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Tropical montane forests are threatened by human-induced fires, resulting in forest patches surrounded by disturbed habitats commonly dominated by bracken fern (*Pteridium* spp.) for long periods. Despite the dominance of bracken in many areas across the tropics, factors limiting tropical forest regeneration have not been investigated. This study assesses the limiting factors on forest regeneration in bracken-dominated areas in the montane forest of Bolivia, offering new insights into how to accelerate forest regeneration in such areas. We experimentally investigated the effect of bracken on natural seedling recruitment in terms of species richness, seedling survival and growth of tree and non-tree species. We also compared species richness and density of seeds and seedlings with increasing distance from the forest edge. Tree species corresponded to 25% of the species pool in the disturbed habitat, but had overall low densities. Tree species richness and density of seeds and seedlings decreased with distance from the edge to the disturbed habitat, suggesting seed limitation. Tree species had high survival and growth rates at the disturbed habitat, especially under bracken fronds, suggesting little establishment limitation. Bracken frond removal even reduced seedling survival and growth of tree and non-tree species. Our results suggest that the main limiting factor of tropical montane forest regeneration in bracken-dominated habitats is low seed dispersal and that bracken fronds could facilitate seedling survival by providing a suitable microclimate for tree establishment. We recommend seed addition of large-seeded tree species directly into the bracken vegetation to accelerate forest regeneration.

045.03 - Analysis of the gorse seed bank (*Ulex europaeus* L.) in the Cerros Orientales de Bogotá, Colombia

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The study of the seed bank allows to understand the different ecological processes that help in the restoration of ecosystems by potentially reactivating the reservoir of genetic diversity contained in the soil, for native species maintenance and recovery. However, the seed bank can also indicate ecological problems when it is composed by exotic species, as a response to disturbances. The aim of this study was to quantify the seed density of the invasive shrub gorse (*Ulex europaeus* L.) in the edges of the scrub in the Cerros Orientales of Bogotá. We sampled the seed bank of the invasive species in six sites located between 2,700 and 3,200 masl, in four intervals of depth from 0 to 20 cm. Subsequently, we used the method of direct seed count method, and the data were processed and analyzed with nonparametric tests. The results show the highest density of seeds in the upper soil layer, from 0 to 5 cm. Significant differences were found among sampling points in seed quantity at different altitudes as well as among depth intervals evaluated. We consider that a high potential to increase the invaded areas exist, indicating the need for a priority strategy of ecological restoration based on the control of the invasive species along these edge areas of the remnants of high Andean ecosystems.

045.04 - Managing *Lantana camara* at a large scale in a dry deciduous forest ecosystem: learnings from the Western Ghats, a global bio-diversity hotspot in India

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A major cause of degradation of forest ecosystems in India is invasion by *Lantana camara*, an exotic invasive weed species introduced to the country 200 years back. By aggressively replacing native vegetation and preventing native seedling recruitment, *Lantana* leads to significant disruptions of bio-diversity, community structures and ecological niches. This results in reduced food availability for herbivores, in turn impacting carnivore populations. *Lantana* also results in higher incidence of unregimented forest fires, monitoring challenges for forest managers and higher human-wildlife conflict arising from agricultural crop raids by wildlife. Junglescapes (www.junglescapes.org) is a grassroots organization engaged in restoring degraded forest ecosystems since 2007 around Bandipur Tiger Reserve - a large Protected Area within the Western Ghats of India, a global bio-diversity hotspot. Over 50% of the Reserve is invaded by *Lantana camara* and restoration efforts were commenced in 2012. *Lantana* was eradicated using the "Cut Root-stock method" i.e. cutting the root-stock manually just beneath the coppicing zone; key benefits being very low *Lantana* regeneration coupled with high survival of pre-existing native plant species. Post-removal management efforts spanning 3-4 years focused on re-introducing native grass and plant species using both active and passive methods. Around 1000 hectares were restored and monitored, showing good resurgence of native vegetation facilitated by a combination of increased resource availability and restoration efforts. Strong negative correlation was observed between native grass and shrub regeneration and *Lantana* re-emergence. Importance of focusing on site selection, post-removal restoration, management of secondary weeds and long-term site management were key learnings.

045.05 - Testing a mulch-based blanket to avoid soil erosion, control the invasion of exotic plant species and restore degraded soils

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Two processes of environmental degradation are common worldwide: soil erosion and invasion by exotic plant species, normally they are managed separately with additional costs. Here we are testing the effectiveness of a simple, cheap product that simultaneously controls erosion and arising of exotic plant species contributing with the local ecological restoration. The product, called here as bioblanket, is constituted by two layers of jute (tissue of vegetal fiber of 5 mm mash), filled with a grass layer

(dead and dried material) with a mix of seeds (hydroseeding). The effectiveness of the product is being assessed through an experiment with natural rain and using eight experimental plots with four different simulations (6m length x 1m width each) constructed in a sloped terrain (about 50%inclination). After every rainfall event the amount of soil loss is quantified, as well as the percentage of germination of seeds, and the percentage of soil surface that has been recovered by the re-growing of the exotic, invader plants (*Bracharia* spp.). Our results indicate high efficacy of the bioblanket in terms of control of soil loss, once the plots covered with blanket treatment got no sediment yield. On the other hand, the efficacy in terms of control of re-growing of invader plants was not yet evidenced, once the invaders plants seem to grow faster than the hydroseeding-related plants. The grass used as an element of the product will also be an additional source of nutrients to the soil after the decomposition, helping in the restoration of the soil.

S47 Let-it-be: When is it an effective restoration approach? - Session 1

Organizer: Karel Prach

S47.01 - The importance of understanding thresholds to spontaneous succession

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Spontaneous succession can be a useful restoration tool. But under conditions where ecosystem recovery is extremely slow and the degraded stage persists for decades or centuries, it may be neither environmentally nor socio-economically acceptable to rely only on spontaneous succession. In that case some level of technical reclamation is needed. The selection of appropriate reclamation interventions should be based on understanding of the thresholds or obstacles to ecosystem development towards target composition, structure and function. Common threshold models assume two main types of obstacles, biotic and abiotic. Dispersal limitation, herbivory and competition are examples of the former, while lack of resources and instability of the soil surface due to erosion exemplify the latter. Experimental and observational studies indicate that different obstacles can apply at the same time, but their importance varies. Results from long- and short-term studies of assisted succession on eroded areas in Iceland show that targeted reclamation interventions can facilitate succession towards native ecosystems, while untreated areas may remain sparsely vegetated for decades. Particular types of reclamation interventions, however, can interfere with colonization of key species and lead to the formation of novel ecosystems. An example will be given of a large-scale, long-term restoration project that is based on a combination of technical reclamation and “spontaneous” succession; where carefully selected, site-specific reclamation interventions are used to accelerate succession towards native woodland.

S47.02 - Spontaneous establishment of woodland in a variety of disturbed sites

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The establishment of potential natural vegetation may represent a theoretical goal of restoration efforts in disturbed sites. Closed woodland represents the expected potential natural vegetation in sufficiently wet (usually over 400 mm of annual precipitation) temperate zones of the world. The aim of this study was to answer the question whether woodland can be established spontaneously in a variety of disturbed sites. We analyzed 13 successional series lasting at least 50 years which were located across the Czech Republic, central Europe. The woody species were classified into early and late successional species. Species typical for the respective potential natural vegetation described for Czech woodland were considered as late successional while all the other species were classed as early successional. Data were processed using multivariate analyses. Cover and the number of woody species gradually increased during succession, and woodland established spontaneously in all series. The cover of early successional species reached its peak on average after 30 to 40 years of succession while that of late successional species gradually increased during the considered period. However, the series largely differed and some of them did not follow the trends. *Betula* spp. (early) and *Pinus sylvestris* (late) appeared to be the by far most frequent colonizer. Spontaneous establishment of woodland can be an effective method for ecosystem restoration in a range of disturbed sites within central Europe due to mostly low proportion of alien species.

S47.03 - Changes in floristic and vegetation structure along a tropical forest chronosequence on abandoned gold-mining land

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The aim of this work was to study the changes in floristic and forest structure in primary succession after mining in Madre de Dios (Peru). We evaluated the floristic, and vegetation structure of reference ecosystem and four zones with different periods of time after mining (between 4 and 22 years). The age of abandoned gold-mining and plot locations were determined using Landsat images (1975-2014). Three plots per site of 20 m x 60 m were used, divided into 20 m x 20 m sub-plots where all individuals with a DBH >1 cm were inventoried. The total height (HT) and DBH of all tree individuals were measured. We determined the Value of Importance, Shannon-Weaver index and Bray-Curtis similarity to evaluate the species diversity and similarity. We used the Non-metric Multidimensional Scaling (NMDS) for similarity ordination and PERMANOVA test to evaluate the differences in floristic. A total of 182 species were registered. The results showed an increase in the basal area, species diversity and similarity from initial regrowth to reference ecosystem of the order of 38 %, 87 %, and 44 %, respectively. The advanced succession had more species in common with the intermediate stage than with the reference ecosystem. Statistically significant differences between initial and intermediate stages ($p < 0.05$) were observed for floristic composition, basal area, HT, and DBH. Considering the gradual recovery of vegetation after abandonment by gold-mining, it is necessary to implement strategies to accelerate this process. As the active restoration that can guarantee the recovery of these areas.

S47.04 - 300 years of natural regeneration of mined areas in rupestrian grasslands

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For more than 300 years, the rupestrian grasslands have been threatened by mining, since gold was discovered in the Espinhaço Range in 1697, and even so, the ecological knowledge on restoration of this ecosystem under natural conditions is still unclear. Therefore, restoration efforts recently made are shallow given the biological importance of the rupestrian grasslands (e.g., plant species diversity and endemism are among the highest in the world) and the irreversible impacts of mining. For this study, we evaluated the composition, structure and edaphic attributes promoted by natural regeneration in two areas of rupestrian grasslands in Mariana, Minas Gerais, Brazil. Both areas were completely degraded due to mining activities, but in one area, mining activity is reported to have happened 300 years ago, while the second occurred 50 years ago. Finally, we observed the relation between the plant communities in each area and its soil features. The collected and assessed data indicated that species richness was much greater in the 300-year old regeneration area when compared to the 50-year old regeneration. The analyzed parameters also indicated a very different structure between the two areas regarding the species composition, which is also related to the differences between the soil parameters. As a result, the necessity to evaluate the damages and the process of natural regeneration reinforce the importance of long term monitoring in restoration areas and the development of techniques and strategies.

048 Governance and public policies

048.01 - The role of public policies in influencing forest restoration in Latin America

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The multiple benefits that forest cover brings to society, including reduced soil erosion, protection of watersheds and water provision, biodiversity conservation and, more recently, climate change mitigation have led to recent commitments by governments worldwide to devote significant expanses of their territory to reforestation and restoration. One of these commitments is the Bonn Challenge, which includes regional implementation platforms such as Initiative 20 x 20 in Latin America and the Caribbean. However, actual on-the-ground reforestation and forest restoration will depend, besides technical and technological issues, on enabling national policies and incentives that inherently vary from country to country.

Countries such as Colombia, Ecuador and Guatemala have drafted specific National Restoration Plans, while many other countries have policies and norms in place that although they do not specify restoration concepts, may lead to forest cover increase either via active or passive approaches either for conservation or production purposes. Bearing in mind this variability we will present the results of a systematic analysis, through a common analytical framework, of the different public policies and legal tools that exist across Latin American countries and the perceptions of relevant stakeholders about the efficacy of these policies and tools. We aim to generate a state of the art review of current policy and normative instruments for enhancing forest cover in Latin America along with key recommendations for countries aiming to draft or refine new policies to effectively implement forest landscape restoration approaches that are explicit, cross-sectorial and inclusive.

048.02 - Forest Landscape Restoration in Peru: Lessons learnt from three decades of practice

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Peru has pledged to initiate the restoration of 3.2 million hectares of degraded lands by 2020 as its contribution to Initiative 20x20, the Bonn Challenge and Aichi targets 14 and 15. The scale of this ambition is unprecedented and its realization can greatly benefit from building on the lessons learnt from previous restoration and reforestation projects carried out in the country over the past decades. We developed an online survey targeting a variety of actors from the public, private and academic sector, and civil society and were able to capture data of 94 restoration projects from the major ecosystems all across Peru. Deforestation, erosion and overgrazing were main reported causes of degradation. While a significant proportion of projects made exclusive use of Eucalyptus sp. and Pinus sp., overall there was a predominant use of native species. However, their use is still far below potential owing to serious deficiencies in availability of technical information about their use and propagation. Local participation was generally restricted to awareness raising activities and implementation of certain restoration activities, with few experiences promoting local organization and decision-making. Most monitoring plans focused on seedling state without considering ecological processes or sociocultural and economic factors. Almost half of the experiences that aimed to generate economic benefits did not monitor progress on them and few exceptional projects that aimed at restoring the original forest cover monitored the recovery of native biodiversity and the effectiveness of ecological corridors. We present recommendations of how to enhance the success and inclusiveness of future restoration projects.

048.03 - National program for the recovery of degraded areas (PNAD) of Peru

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Peru is a South American country with 1,285 km² of extension. Is part of the Amazon Basin and is located in the second place with the largest area of Tropical forests, after Brazil. However, the rate of deforestation exceeds 150,000 ha / year that represents 9 million hectares of deforested land, degraded land on the country's coast and highlands, as consequence of overgrazing and unsustainable agriculture. Because of this, in 2014, Peru makes part of the 20x20 Initiative, for restore 3.2 million hectares of degraded land (2 million with plantations and 1.2 million under different models of assisted natural regeneration). In this way, the Ministry of Agriculture and Irrigation (MINAGRI), through the National Forestry and Wildlife Service (SERFOR), took the lead in fulfilling the commitment, supported with the public and private sector and national and international cooperation, with the purpose to articulate the effort between different institutions to generate the National Program of Recuperation of Degraded Areas PNAD. Finally, the objective of the PNAD is to present the guidelines and strategies at the national level, to recover degraded lands considering the approach of productive restoration, which, generate economic and environmental benefits for the population.

048.04 - Towards a European action plan to boost ecological restoration

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The EU Natura 2000 network of protected areas, which covers almost one-fifth of Europe's landmass and 6 % of marine areas, is the corner stone of Europe's biodiversity policy. In spite of a solid legal framework for nature conservation and restoration in the EU and an ambitious biodiversity strategy, a recent evaluation highlighted that current efforts are insufficient to achieve the desired favourable conservation status of the protected species and habitats. Important challenges remain, including funding shortage, ineffective management and restoration of Natura 2000 sites, lack of policy integration, knowledge gaps, and limited stakeholder and public engagement. In light of these findings, the European Commission is now preparing an Action Plan, to be published in 2017, providing comprehensive measures to substantially improve nature protection on the ground. This contribution will reflect on the proposed EU Action Plan in relation to ecological restoration, in order to assess if the policy proposals can boost ecological restoration in the EU.

048.05 - Linking science and practice, through a focused three-year Reforestation Research partnership, for restoration-related knowledge generation in Durban, South Africa

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Developing world cities are working hard to embrace the world's recently adopted Sustainable Development Goals (SDGs), as a means to address widespread poverty, inequality, and growing environmental degradation. The use of research, to interrogate and understand the challenges, is considered critical as it allows for meaningful and practicable policy and management tool development. EThekweni Municipality (Durban, South Africa), recently concluded a focused three-year Reforestation Research partnership with the University of Kwa-Zulu Natal (UKZN). Founded on a framework of multi-disciplinary partnerships, the initiative set out to address knowledge shortages in a range of restoration related topics. These included: optimising forest biodiversity, while simultaneously addressing climate change adaptation and mitigation concerns; and, socio-economic development in the context of rapid urbanization and competing pressures for scarce natural resources. It was anticipated that the broad base of disciplines would ensure enhanced cross-sectoral knowledge sharing. Funding was made available for 15 post-graduate student-based research studies from a range of disciplines. A secondary aspect of the initiative sought to build local research capacity, including the development of research skills and competencies, of University and Municipal staff. Knowledge generated from the partnership is already being used to improve planning and management of restoration activities. This includes

the development of new cross-sectoral SDG-related policies. These policies have helped secure support from leadership, as well as from politicians, who are considered critical champions in ensuring support for the up-scaling or mainstreaming of projects.

048.06 - From vegetation mapping to restoration and landscaping with native plants in Kuwait

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Kuwait's Native plants classification and distribution began in the mid fifties when Dame Violet Dickson published the first book on the wild flowers of Kuwait. The first vegetation map was developed by Dickson in 1955, which was later modified by several authors in 1963, 1969, and 1974 and more recently by the author in 2000. In 1975, Kuwait realized the need to establish protected areas for conservation and management of the range plants. A 20-km² area was designated to protect and manage the *Rhanterium epapposum* and *Cyperus conglomeratus* plant communities. Conservation efforts were extended to cover more plant communities such as *Haloxylon salicornicum*, *Panicum turgidum* and some halophytic species. In 2016, the total protected areas in Kuwait covered 165,708 ha (1657 Km²). These efforts resulted in conservation of the genetic diversity of the native plants and provided the needed resources for native plants production. Some successful plants included *Rhanterium epapposum*, *Atriplex leucoclada*, *Atriplex halimus*, *Panicum turgidum*, *Farsetia aegyptia*, *Lycium shawi*, and *Nitraria retusa*. These plants have shown ability to reproduce under managed farming system and seeds can be collected to generate more seedlings for large-scale restoration and landscaping. Having realized their potential, local producers are currently commercializing seeds and seedlings for landscaping and restoration activities as well as for gardening and open spaces in urban areas. This paper presents a successful story of the role of science in development of know-how for native plants production for ecological restoration and social-economic benefits.

050 Restoration in the context of agroecosystems/ agroforestry

050.01 - Development and financial analysis of agroforestry systems for small-scale producers in Southern Brazil

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In light of the ambitious restoration goals recently announced by the Brazilian government (Bonn Challenge, 20X20 Initiative, INDC), and because of current environmental laws, there is a need to develop restoration methods that enhance ecological efficiency while also optimizing implementation costs and maximizing income from various forest products. A large scale project initiated in 2010 that aimed to restore approximately 15 ha of abandoned agricultural fields in Embrapa's Research Station in Caçador (Santa Catarina State, Brazil) was used to test different methods of restoration based on agroforestry systems. These systems combined well-known traditional native forest species with those of economic value. The systems took advantage of processes and ecological interactions that occur in natural forests in order to create improved environmental conditions for the development of various species. Specifically, we use valuable fast-growing pioneer species (*Mimosa scabrella*) to create a forest cover under which other economically valuable species have ideal conditions to grow, such as *Araucaria angustifolia*, *Ilex paraguariensis*, and several fruit species (Myrtaceae). Embrapa and The Nature Conservancy have established a partnership to financially analyze these agroforestry systems. Six years after implementation and continuous maintenance of the systems, we have successfully restored the project area and can now evaluate the costs involved in implementation, the economic return from the products already obtained, and model the viability of these systems for periods of 10, 20 and 30 years. Initial financial analysis for systems based on *M. scabrella*/*I. paraguariensis* showed relatively high cost-benefit ratios (1.5-2.8) with long payback periods (8-11 years).

050.02 - Forest Cocoa Project: Income generation and forest restoration as alternative to Amazon deforestation in south Pará State in Brazil

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The municipality of São Felix do Xingu is located at Amazon deforestation arch in south of Pará State in Brazil. This region has been suffering high deforestation pressure due pastureland expansion for beef cattle ranching production for last 30 years. Smallholder agriculture is responsible for 40% of deforestation rates at this region. On the other hand agroforestry systems (AFS) offer a good alternative for family farmers sustainable income. Cocoa tree (*Theobroma cacao*) is native to the Amazon Rainforest and is a good species for intercropping with agricultural Amazon trees through AFS in the same time the generate important income for smallholder producers. In this context, The Nature Conservancy in partnership with Ceplac, Embrapa, World Agroforestry Center, the State Pará Government and São Félix do Xingu municipality have been working since 2013 to run Forest Cocoa Project activities. Since 2013 Forest Cocoa project engaged 100 families and supported producers to implement new cocoa plantations, improve their abilities to manage AFS and restore degraded areas to be compliant to forest code. In order to expand qualified rural technical assistance to promote AFS and forest restoration in the region three participative demonstration units (PDU) were established in 2015. Each PDU attends nowadays an average number of 25 families but can reach a total number of 60 cocoa producers families. Forest Cocoa Project goals for 2020 are: new 5,000 hectares of cocoa plantations in AFS; 1,000 families engaged; 2,000 hectares of degraded riparian areas (APP) restored.

050.03 - Agroforestry System under different management contribution to carbon sequestration and environmental gains after gully erosion stabilized area in Pindorama, Brazil

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A gully-eroded landscape in a Kandiuistalf soil area was emerged in Pindorama, Brazil due to inadequate agricultural activities. In 1997 stabilization actions started to restore original water flow, stopping erosion and recovering soil and vegetation sustainability. Four dams with four ponds were built. As a second phase of the restoration, in 2011 an agroforestry system with 28 native tropical forest species plus annatto and rubber tree was planted on the ponds edges and four treatments were adopted : T1 (Mower coupled to the tractor, trees planted in hollows, spacing 3 x 2 m without cultivating or fertilization between lines); T2 (herbicide, planting in hollows, 3.5 x 2 m spacing, maize cultivated between lines); T3 (plough, harrow, scarifier, planting trees in furrows, 3.5 x 2 m spacing, with maize between lines); T4 (plough, Harrow, scarifier, planting trees in furrows, 3.5 x 2 m spacing, with no plantation between lines). The different planting techniques and tillage influenced soil attributes and vegetation. Live trees carbon stock of the agroforestry system in 2014 was estimated as 5.98 T/ha and in 2016, T1 that had the higher carbon stock was 104.2 T/ha, T2 was 44.91 T/ha, T3 39.25 T/ha and T4 29.54. The total carbon stock in 2016 was 217.92 T/ha. Soil organic matter increased in all treatments from 2011 (T1-8,5% T2-10%, T3- 11,5% and T4-11 %) to 2015 (T1-19,7% T2-19%, T3-21,2% and T4-18,2%). Annatto production increased with the increase of productive trees, number of fruits per tree and seed weight in all treatments during the evaluated period.

050.04 - Nucleation theory inspiring the design of High Biodiversity Silvopastoral System in the Atlantic Forest Biome: ecological restoration, family farm livelihood and agroecology

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Agriculture is the most important sector of the global economy. Conventional agriculture however may be the greatest threat to global ecosystems. This dilemma plays out in the Atlantic Forest Biome, where only 15% of the original forest remains, most lost to pastureland and agriculture. High Biodiversity Silvopastoral Systems (SSP+nuclei) were designed in a participatory framework to embrace ecological restoration, agroecology and livelihoods. Our goal was to provide shade, revenue from non-timber forest products (NTFP), biodiversity (50 native tree species/ha), connectivity, and an improved landscape matrix. In each hectare 40 nuclei (5 m x 5 m) were fenced off (10% of the pasture area). Inside we planted four functional groups of native trees enhancing succession. In the first year, 8 native pioneer trees were planted with 4 bananas in each nucleus. In the 3rd to 4th years plantings were enriched with high value successional species, 8 *Euterpe edulis* (açai) and 2 climax species. SSP+nuclei has been implemented in 5 pilot farms in Southern Brazil where biophysical variables have been measured – soil quality and carbon, biodiversity, microclimate, carbon sequestration and landscape characteristics. The system provided shade by the 2nd to 3rd year, produced banana and rose pepper in the 4th year, açai from *Juçara* and charcoal in the 7th. Shaded area depends on tree pruning management. Farmers recover restoration costs by the 7th - 8th year with revenue from NTFP. Redesigning Agroecosystems Research Group strives to develop agricultural landscapes that synergistically restore the environment while enhancing livelihoods in the Atlantic Forest Biome.

S54 Big Ideas l Big Practice - Are We Action Ready?

Organizers: Paddy Woodworth and Justin Johnson

S54.01 - Big Practice: Ecological restoration on a global stage

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Interest in, and attention to the pressing need for large scale restoration of ecosystems around the world has grown significantly in recent years. Governments and conservation-focused institutions have shown a willingness to engage in these ideas, and a number of ambitious targets have been set to signal commitment to these initiatives. This has occurred at a time when the relatively new field of 'ecological restoration' has undergone challenges to previously agreed objectives, where the suggestion has been raised that the targets/goals of practice become less specific (i.e. novel, not historic). Concurrently, the need for improved natural resource management and the launching of sustainability initiatives for existing production enterprises has increased with the recognition of how these land uses affect and rely on ecological services. At this current time, with more than 100 million hectares slated for 'restoration' globally, a clear understanding of the differences in costs, outcomes, and operational capacity, of different types of practice, requires clear consideration. In presenting a selection of contrasting projects from around the globe, an operational evaluation will be presented to explore the current interface between theory, business and practice. Is there a global price-per-hectare cost we can determine for restoration? Are there operational models which can undertake 'restoration' at scale while still maintaining local stakeholder involvement? With a world of opportunity, how can we prioritise our efforts?

S54.02 - Big Practice: Who's going to pay for restoration?

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To achieve restoration targets recently introduced by global initiatives seeking to restore degraded land around the world, innovative approaches to finance are required. To explore these opportunities, we will discuss new approaches to finance restoration at scale. In particular, examples of how private finance can play a much bigger role in global restoration initiatives will be presented. The role of Public Private Partnerships that can deliver returns on capital investments in addition to environmental and social impact benefits will be explored. Drawing from the work of WRI's New Restoration Economy initiative, we will present some of the critical bottlenecks identified in enterprises working on large-scale restoration projects. We will address some of the characteristics of scalable business models, and highlight examples we see currently in the restoration space.

S54.03 - Four Returns: A Long-term Holistic Framework for Large-scale Landscape Restoration involving Business.

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The global restoration community is entering a new era that is characterized by projects that are large-scale, economically-viable and socially-inclusive. Large investment funds are getting ready to participate. However, the project-pipeline to accommodate this kind of investments is missing. We need to scale up, to speed up and do this smart. Commonland envisions large-scale landscape restoration activities involving businesses by building transformative business cases with local farmers, land users, and experts. In this way, the urgent need for project pipelines towards (institutional) investors will be bridged. The impact of Commonland projects translates into 4 returns® on investment: return of inspiration, return of social capital, return of natural capital, and return of financial capital. Commonland is road-testing this approach in landscapes over 500,000 hectares in Aus-

tralia, South Africa and Spain in order to deliver proof of concept for large (institutional) investors to participate in the transformation of large-scale restoration projects into pipeline ready investment opportunities. Designing and implementing restoration projects that are effective, efficient, and engaging will enable businesses and investors to reduce risks and cost-effectively scale-up restoration efforts. Consequently, these will become part of mainstream activities and investment portfolio's by the private sector. We will explain the 4 returns approach, the challenges and the lessons learned from implementing restoration projects according to this approach for enhancing the project pipeline for investable restoration initiatives.

S54.04 - Big Practice: Upscaling restoration. The Experience of South African Natural Resource Management Programmes

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It can be said that conservation, restoration and management of natural resources more specifically watersheds in South Africa started 72 years ago, with the seminal report "Preservation of the Vegetation of the South Western Cape" (Wicht 1945). That publication captured the essence of a multidisciplinary approach best suited to conserve the Fynbos biome of South Africa's Western Cape Province. Three quarters of a century later the target of arresting land degradation is still present, however Wicht's message remain current. This presentation will provide an overview of current land use in South Africa, the extent of natural resource degradation, and a summary of programmes developed to address these challenges. A summary of what is still required to meet the increasing scale of restoration targets will be presented in the context of our existing programmes, which have evolved from a focus purely on invasive alien plant control, to an integrated veld and forest fire management, watershed, bush encroachment and wetland restoration approach. An assessment of what is required to better meet the national demand for restoration and maintenance of South Africa's renewable natural resources will be considered based on recent practical experience and applied research of current programme financing. This will be followed by a detailed look at current institutional arrangements, and an assessment of whether they can adequately achieve the ultimate restoration goals. Consistent across all themes presented, will be the substantial socio-economic benefits gained from our programmes within the context of developing countries like South Africa.

S54.05 - Big Practice: Multi-stakeholder coalitions for making restoration happen at large scales with shared benefits

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Large-scale ecological restoration in agricultural landscapes relies on permanent land use change with areas set aside for the recovery of natural ecosystems. Changes to landscape configurations can lead to improved socio-ecological benefits with multiple stakeholders being involved in, and affected by, restoration interventions. A participatory approach to govern restoration programs is essential to anticipate solutions for emerging conflicts and share benefits. However, the community of restoration professionals is still poorly organized, and may thus have limited capacity to promote large-scale restoration through innovative policies or to mobilize public and private funding to finance restoration programs. Here, I describe how a multi-stakeholder coalition in Brazil – the Atlantic Forest Restoration Pact – has fostered a new governance model to promote large-scale restoration of tropical forests. The solutions developed by the Pact include the development of new legal instruments and funding schemes to support restoration, while also mobilizing society for achieving higher levels of public support for restoration programs. This coalition is formed by NGOs, private companies, governments and research organizations to integrate the different views of restoration, and decentralized units of planning were established in different states to increase the representation of stakeholders. Funding and political support is still a major problem to upscale restoration, but our early experience with the Pact has shown that these bold challenges can only be overcome if restorationists work together to obtain support at the higher levels of political and economic decisions.

S55 Business and Livelihood Supporting opportunities in rehabilitated water basin (catchment): The case of Okhombe community in South Africa

Organizer: Bonani Madikizela

S55.02 - International perspectives and lessons on restoration with focus on supporting society and business

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In this so-called “Age of Restoration”, multiple local, national, regional and global restoration targets have multiplied across the globe. Over the next two decades, restoration might become the first or second dominant land-use change driver on the planet. In this context, it is essential that science and policy adopt an integrated land-use perspective that considers and illuminate the interdependencies between production, conservation and restoration over a limited land base. It is also key that the distribution of restoration costs and benefits across different spatial scales, from local to global, are properly accounted for and incorporated into policy planning and implementation. Local restoration initiatives provide global benefits, and these externalities should be properly compensated for so that optimum restoration levels are achieved. Restoration projects fully or partially financed by REDD+ and other carbon-related finance are already a reality. The distribution of restoration costs and benefits should also impact restoration spatial planning at multiple scales. Finally, experiences gathered from large-scale restoration programs implemented over the last decades can offer valuable insights into nascent restoration goals in other countries. This talk will explore how the consideration of these topics can increase the benefits of and reduce the risks posed by these ambitious restoration goals.

S55.03 - Restoring key ecosystem processes to enhance natural capital: a case for Lake St Lucia restoration linked to rural livelihoods

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The biodiversity assets and natural resources of the Lake St Lucia system within the iSimangaliso Wetland Park are recognised internationally. Recent studies have shown that access to these natural resources is an important component of the livelihoods and survival strategy for households in and adjacent to the Park. Low levels of education and employment, the remoteness of these areas, and social strains related to the difficult history of the area, means that people are still highly reliant on the land and natural resources to supplement their incomes and meet their needs, both directly and indirectly, through conservation and tourism. A wide range of terrestrial and wetland resources contribute to the security of these complex livelihoods and the quality and quantity of the harvested resources, including estuary dependent shrimp and fish, moist grasslands for grazing and saltmarsh rushes and sedges is based upon healthy estuarine functioning. The last decade has seen a decline in estuary functioning which has resulted in declines in the availability of these resources. It is important that there is a good understanding of both the resources and their key system drivers to support appropriate restoration actions which will in turn support and improve livelihoods. Recent studies have evaluated the costs and benefits of the identified restoration actions to improve estuary health. The restoration of Africa’s largest estuarine lake will increase its natural capital and it is anticipated that this will become visible through the improvement of the societal value of ecosystem services.

S55.04 - Developing green innovations and technologies through community engagement and capacity building

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Water, energy and food security form the basis of a self-sufficient economy. However, one of the factors affecting South Africa's ability to achieve this is limiting resources particularly in rural areas. One of the aims of the Green Village Project is to improve the economic conditions of communities living in the Upper Thukela catchment area through demonstrations of how green innovations and technologies can be integrated into their rural livelihoods to reduce over-reliance on fossil fuels for energy supply. Capacity building of the community members was carried out for each of the technologies. The experiences of the community members were documented to determine (i) the social impact that the technology would have on the community, (ii) the impact that the technology would have on the environment and (iii) the economic implications of the green energy technology. The results will enable the development of a business plan concept which will indicate the potential for job creation and the development of small, medium and micro enterprises in rural areas.

S55.05 - A monitoring and evaluation framework for wetland restoration in South Africa, using an urban wetland case study.

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Wetland restoration in South Africa has expanded to include both government and commercially funded projects within a range of socio-ecological landscapes. As such, a monitoring and evaluation (M&E) framework was required to provide structured guidance within the context of strategic adaptive management and recognizing wetlands as social-ecological systems. An M&E framework for wetland restoration projects was therefore designed for application by a range of different users, including national programmes, consultants and environmental managers. The framework was developed based on a participatory and evidence-based approach, and is underpinned by rationale which draws from the following: wetlands as socio-ecological systems; learning as a means of strengthening practice; adaptive management; ecosystem resilience; and the value of ecosystems need to inform restoration. To refine the framework, a case study of the Greater Edendale Mall (GEM) wetland located in Pietermaritzburg South Africa, was undertaken. The GEM wetland occurs within an urban setting and was rehabilitated as a condition of environmental authorisation as mitigation associated with the development of the GEM. The wetland provides an unusual case study in that restoration incorporated achieving a desired state rather than solely focussing on restoring near-natural conditions. The project outcomes have provided some interesting insights into the adaptive management requirements of urban wetland rehabilitation, the likelihood of achieving onsite mitigation considering external socio-ecological factors, and refinements to the M&E framework. Furthermore, the wetland has served as a catalyst for environmental awareness and promoting wetland restoration projects in the broader landscape.

056 Community engagement in ecological restoration: implementation

056.01 - The development of a holistic means to stabilise dryland erosion associated with cattle paths by testing and introducing ecological engineering and citizen science within the Okhombe community, KZN, South Africa

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Land degradation is a key environmental issue experienced at a global scale, as it continues to threaten the sustainability and agricultural capability of land. In South Africa, livestock cultivation and ownership plays an extensive role in the livelihoods and cultural heritage of many communities. Unfortunately, soil erosion associated with overgrazing and agricultural activities are increasingly becoming a problem as arable land is lost as a result of various dryland erosion processes. The Okhombe Valley, situated within the Upper Tugela catchment, KwaZulu-Natal, has been severely impacted upon by extreme gully erosion, loss of vegetation and the stripping of topsoil as a result of cattle and poor land management. Extensive research and rehabilitation initiatives have been implemented in the valley to slow these erosion processes, however no solution has been found. The University of KwaZulu-Natal, in collaboration with the Water Research Commission, are striving to understand the geomorphological processes occurring along previously rehabilitated portions of the study site to better understand the drivers of gully erosion within the area. Using the information collected, an ecologically engineered rehabilitation approach will be implemented along the length of degraded cattle paths in an attempt to find a holistic solution to the continued degradation. In addition, a citizen science tool used to define the physical soil properties will be developed and tested at this site; training the community to use and test the efficacy of this tool in conjunction with other monitoring tools to measure and evaluate the outcomes of dryland rehabilitation.

056.02 - Beyond Digging a Hole: Engaging Community Volunteers to Develop Restoration Site Ownership

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Ecological restoration is an excellent tool for engaging the public at all levels of interest and expertise. Many habitat restoration projects are mandated mitigation by impacts to that habitat type. These projects are monitored and maintained for a specific time frame until success criteria are achieved (usually 5 years). As these project sites age without management, they are susceptible to degradation by invasive plant species and vandalism. Involving the local community with long-term maintenance is part of a solution for long-term success for habitat restoration projects as they evolve to land management projects. The explanation of natural history and cultural history on a restoration site are often necessary to provide the context that takes a volunteer beyond the task at hand to see the larger restoration goals. In this presentation, environmental education methods and techniques that will broaden a sense of community ownership over the restoration site, thereby increasing the chances of long-term project success will be proposed. We are currently implementing this philosophy on two different projects in southern California that have been signed off as successful mitigation projects. Incorporating this into policy when habitat restoration plans are developed could provide the low maintenance funding needed to continue the success of these projects.

056.03 - Corridors for life: improving livelihoods and connecting forests in Brazil.

LAURY CULLEN

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Land-reform, agribusiness and environmental movements, revitalized by the democratization of civil society in Brazil in the 1990s, found their objectives in conflict over forested parcels that settlers and large landowners want for conversion to agriculture but that are important for landscape conservation. In the Atlantic Forest, where 95% of the forest is gone, we present a case of an Brazilian organization engagement with the land-reform movements and agribusiness with respect to forest remnants neighboring protected areas that have insufficient habitat for the long-term survival of unique endangered species. Large continuous forest corridors, agroforestry stepping stones and buffer zones are implemented as restoration approaches. In the Pontal do Paranapanema (São Paulo), where IPÊ - Instituto de Pesquisas Ecológicas has supported agricultural alternatives that improve livelihood and farmers options and provides incentives for habitat conservation planning. Where land-reform groups and large farmers were better organized, technical cooperation on settlement agriculture permitted the exploration of mutual interests in conciliating the productive landscape with rural landscape planning and conservation objectives.

056.04 - Socioeconomic impacts of restoration: The case of Mutirão de Reflorestamento in Rio de Janeiro

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Over the last decades, there has been an increasing number of restoration projects that has been evaluated using socioeconomic indicators. This study assessed socioeconomic effects and perceptions of a large-scale urban restoration project named Mutirão de Reflorestamento (MdR), that restored over 2000 hectares in the city of Rio de Janeiro since 1982. The study also proposed recommendations based on social surveys with the local communities. We conducted focus groups and individual interviews in eight communities with MdR's participants and people who were not involved into project. Regarding those not involved or familiar with the MdR, 34% considered ecosystem services linked to air quality as the greatest benefit of the forest. Among those who knew MdR, the main benefit perceived was increased environmental awareness of the community (14%) and the main negative aspect was the lack of Labor Rights for MdR staff (19%). For MdR's staff, the job and income was one of the greatest benefits of the project (18%), and the lack of Labor Rights (41%) the main negative aspect. Regarding suggestions for improvements, both those working for MdR (41%) and those not working on it (18%) indicated the adequacy of the Labor Rights as their main suggestion. The results showed that the project perception of both groups was similar. This shows cohesion among those directly involved in the project and the local community, highlighting the importance of community-led projects for the long term sustainability of restoration projects.

056.05 - Restoring the Mauritia's palm swamps: A participatory approach in the Colombian llanos

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Mauritia palm swamps are among the most important ecosystems in the Colombian llanos, due to their role in providing environmental services. Increasing intensity and frequency of fire clearings for cattle ranching has severely diminished these ecosystems. Yoluka NGO together with local communities along the basin of the Bitá River (Puerto Carreño- Vichada-Colombia) designed conservation actions for Mauritia palm swamps through an adaptation of the Open Standards for the Practice of Conservation in several workshops. The community identified ecological restoration as an important tool for the conservation these ecosystems in the workshops. To plan the restoration process appropriately, we characterized Mauritia's palm ecosystem by evaluating the spatial distribution, the structural types, diversity and species composition, the disturbance regime and constraints to restoration. As a result, we identified three physiognomies for Mauritia forests, ranging between open, dense or mixed, corresponding to successional stages between savanna and gallery forest. Parallel to this, the local communities acquired skills in nursery construction, seed processing, seedling production and environmental education skills to maintain this process. These

communities produced 8816 *Mauritia* seedlings and 220 native tree seedlings in one year of operation of three nurseries built by them. These were planted on 12.71 hectares following two arrangements, looking for a dense *Mauritia* swamp in the medium term (5–8 years). Seventy ha were isolated through electric fence and firebreaks, including the areas planted. We also did an international fire management workshop with the communities and designed a wildfire protection plan based on association of local communities.

056.06 - Surveying energy behaviour and needs - the first phase in developing rural community development options

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Establishing community development options, programmes and technologies is something that should be done with the needs of the community at the forefront of the research. Despite this being a known and understood concept, it is often one that is partly or wholly ignored in rural development. In an effort to avert this situation in developing a South African based research project, the Green Village Project, the research team engaged closely with community members – through community workshops and community wide surveys – to understand their energy needs and common practice. We present here some of the findings of this research: (i) energy usage and related behaviour, (ii) preferences for various types and forms of energy, and (iii) how these have altered over a five-year period, with comparison to an energy survey conducted in the same area in 2011.

057 Forest influences on hydrological processes

057.01 - Forest restoration plantings and rainfall interception: Implications for water ecosystem services and forest management

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Major investments have been applied to restore tropical riparian forests degraded by human activities, in order to safeguard the provisioning of water ecosystem services. However, the Brazilian forest restoration programs need scientific bases to support monitoring and making decisions about the water resources. This study aimed to evaluate the effectiveness of Atlantic Forest restorations in recovering hydrological processes and providing water services. In eight restoration plantings, established 10 years ago by active restoration and high diversity of tree species, we assessed Precipitation (P), Throughfall (Th) and Canopy Interception (CI) processes. We randomly fixed 80 throughfall collectors inside the plantations (10/area). We sampled the collectors monthly during a year. We also assessed the role of forests attributes on rainfall interception. We identified a high variability of annual CI among the restoration plantings, ranging from 14.9% to 26.4% of total P. These findings suggest outcomes similar to native forests at initial, intermediate or even advanced successional stages. Our analyses show that CI variability depends on basal area ($R^2 = 0,6785 - p < 0,05$), which in turn is closely correlated to forest composition (species richness; $R^2 = 0,8927 - p < 0,01$). The results highlight and strengthen the potential contribution of young restoration plantings to vital ecosystem services such as soil protection and water regulation, which depend of rainfall interception and redistribution into the ecosystem. Correctly planning the management of basal area could benefit this part of the water cycle and, consequently, ensure important ecosystem services of tropical landscapes.

057.02 - Do seasonal tropical forests act as a sponge and, if so, can we restore it?

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One of the biggest development challenges faced in the 21st century is access to abundant fresh water. While it is often assumed that forests regulate the hydrological cycle in the moist tropics by enhancing dry season stream flow, the evidence to support this has been limited and the ecosystem service itself in dispute. Nevertheless, policy makers and practitioners call for reforestation in order to restore this ecosystem function, often referred to as the sponge effect. The Agua Salud Project was established in the moist steep-land forests of the Panama Canal Watershed in 2008 to study the ecosystem services provided by seasonal tropical forests and how they change with land use and climate change. Nine watersheds that include mature forest, pasture, and different active and passive reforestation treatments have been monitored constantly since 2008 to both test forests ability to regulate the hydrological cycle and how these different land management techniques can restore this ecosystem function. All reforestation treatments were initiated in 2008. At the same time we monitored tree growth in forests and plantations as well as biomass of grasses in pastures. In this presentation we will first present data verifying the sponge effect at our site. We will then present stream flow data from different reforestation treatments and discuss the extent to which different land uses begin to restore this ecosystem function. Finally we will discuss tradeoffs between tree growth, carbon accumulation, and streamflow across land uses.

057.03 - Modelling the Surface and Groundwater Interactions of Potential Agroforestry Systems for Use in Forestry Rehabilitation Programs in a Water Stressed Catchment of South Africa

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In water-stressed catchments of South Africa there is a need to investigate the potential hydrological gains of agroforestry systems as an alternative to commercial forestry, which currently dominates large areas of the country. Along the Maputaland coastal plain, a landscape level mixed agroforestry system of plantation forestry, agricultural activities and expanded human settlement has severely altered the hydrological regime, particularly the groundwater recharge which is a vital water resource to the communities living in the area. In order to understand the regional surface and groundwater interactions, vegetation water use and groundwater fluctuations of prospective agroforestry vegetation types were monitored over a two year period in the Maputaland coastal plain. The Soil and Water Assessment Tool (SWAT) model, which has emerged as one of the most widely used water quality watershed and river basin-scale models was coupled with the 3D transient flow model MODFLOW. The heat pulse velocity (HPV) and the eddy covariance techniques were used to calibrate and validate the model simulations. The results show that the commercial forestry systems use significantly more water than the indigenous grassland and forestry systems. The highest drawdown levels occurred within and surrounding the commercial forestry areas. This clearly supports the hypothesis that the introduced plantations have a significant impact on the groundwater levels. Furthermore, the promotion of water efficient agroforestry systems for rehabilitating previous exotic commercial plantations could significantly improve the poor hydrological state of water stressed catchments in South Africa.

057.04 - Rehabilitation of Alien Invaded Riparian Zones and Catchments Using Indigenous Trees: An Assessment of Indigenous Tree Water-use

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Trees can be used for catchment rehabilitation and riparian zone management. The impact of expanding rehabilitation programs using indigenous trees is of critical importance in a water scarce country. The question then is whether these indigenous species use less water than the fast-growing invader stands? Water-use within a riparian forest along the Buffeljags River in the Western Cape of South Africa was monitored over a three year period. The site consisted of an indigenous stand of Western Cape afrotemperate forest adjacent to a large stand of introduced *Acacia mearnsii*. The heat ratio sap flow technique measured the water-use of a selection of representative indigenous species in the indigenous stand and *A. mearnsii* trees in the alien stand. The indigenous trees showed significant intraspecific differences in sap flow rates, varying from 15 to 32 L•day⁻¹ in summer. In winter (June) this was reduced to 7 L•day⁻¹ when there was less available energy for transpiration. The combined accumulated daily sap flow per year for the *Vepris lanceolata* and *A. mearnsii* trees was 5 700 and 9 200 L respectively, demonstrating the higher water-use of the *Acacia* trees during the winter. After spatially upscaling the findings, it was concluded that the alien stand used six times more water than the indigenous stand, showing that there would be a significant hydrological gain if the alien species are removed from riparian forests and rehabilitated back to their natural state.

057.05 - Rainfall interception by secondary forests on abandoned pastures in northwestern Costa Rica

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Secondary forests are a major forest cover in the tropics, but their effect on ecohydrological processes has been rarely studied. We used a functional approach to assess if forest type and canopy functional properties drive rainfall interception. Throughfall and canopy functional properties were measured in 0.12 ha plots in two floristically different types of secondary forest (n = 18) in northwestern Costa Rica using 21 fixed collectors within each plot in a systematic grid square sampling pattern. Independently

of forest type, median interception was 15% of gross precipitation (range 2-28%) during our 45-day study period. Its median coefficient of variation (CV), as a measure of within-plot spatial variability, was 128% (39-1023%). Results indicate that taxonomic and functional composition of dominant species may differ without having an effect on rainfall partitioning. At the plot level, rainfall interception was positively associated with community-weighted mean leaf thickness, while interception CV was mainly associated with the abundance and three-dimensional distribution of canopy elements. We found lower interception values for these forests restored by natural secondary succession on abandoned pastures than those reported for other lowland secondary forests in Costa Rica. Our results suggest that weighted mean leaf traits, particularly those associated with leaf structural resistance, are as important as canopy structural elements in the partitioning of rainfall by the forest canopy. This study supports the importance of taking canopy functional properties into account when assessing ecohydrological processes like interception and further develops the possibility of a functional approach for evaluating hydrological ecosystem services provisioning.

057.06 - Relation between water supply and restoration in burned plantations of *Pinus radiata* and *Eucalyptus globulus*

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During the dry summer of 2017 one of the most massive fires worldwide affected Chile. Around 570.000 ha were burned; around 55% of them were *Pinus* and *Eucalyptus* plantations. Within the context of the debate about water consumed by plantations, and whether to plant native or fast growth species, we recorded the changes in water supply in fire affected areas and willingness to restore of the affected. Before the autumn rain arrived, 60 people which live in burned areas, were interviewed regarding whether the water supply of springs, streams, wells and rivers had changed after the death of plantations. Geographic coordinates of water sources mentioned by the interviewees were recorded. Using satellite images we checked the distances to fire and density of burned trees in the areas where the water courses occur. 88% of the people interviewed say that the water level increased after fire, 3% say it decreased and 9% say it did not change. The analyses show us that the areas where the interviewed people say the water supplement increased, had been covered mainly by plantations at distances less than 30 m from water courses. Only one of the owners considers planting *Pinus* or *Eucalyptus* again, others did not know yet (7%), and the others prefer to recover with native species, because it is less water demanding and less inflammable. We discuss the results in relation to the policy of planting fast growing species vs. native near water sources in Latin America.

S59 Let-it-be: When is it an effective restoration approach? - Session 2

Organizer: Karel Prach

S59.01 - Natural regeneration of secondary Neotropical savannas in abandoned pastures protected from fire

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Millions of hectares of tropical savannas shall be restored in the next decades to comply with global biological conservation agreements. Thus, research involving the dynamics of already converted old growth savannas (OGSs) is important to guide restoration efforts. We constructed a chronosequence (3 - 25 yr) to investigate the trajectories of secondary vegetation of Neotropical savannas (the Brazilian Cerrado) in abandoned pastures protected from fire (31 sites), and estimated the time required for these ecosystems to reach the standards of either reference OGS or encroached savanna (cerradão). Attributes of the woody plant community (canopy cover, richness of adult trees, richness of woody plants, richness of shrubs and density of young and adult trees) as well as ground cover by native vegetation (all life forms) predictably increase while ground cover by exotic grasses decreases over time. However, changes over time in community attributes exclusively related to herbaceous species (ground cover by either native grasses or native forbs) are not predicable and their recovery not possible. After conversion in planted pasture and subsequent abandonment, the OGS do not spontaneously return to a pre-disturbance state, but after estimated six decades the community will become similar to encroached savanna (alternative state). If the restoration goals enfold the recovery of OGS's biodiversity and ecosystems services, restoration interventions including fire management are required at least to avoid woody encroachment. From the indicators used, we recommend the ground cover by native vegetation and richness of woody plants as indicators to monitor the recovery of Neotropical savannas.

S59.02 - Ecological restoration success is higher for natural regeneration than for active restoration in tropical forests

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Is active restoration the best approach to achieve ecological restoration success (defined as a return to a reference condition, i.e. old-growth forest) when compared to natural regeneration in tropical forests? Our meta-analysis of 133 studies demonstrated that active restoration did not accelerate restoration success relative to natural regeneration in tropical forests for three taxonomic groups (plants, birds, and invertebrates) and five measures of vegetation structure (cover, density, litter, biomass and height). Biodiversity and vegetation structure were 34–56% and 19–56% higher in natural regeneration than in active restoration systems, respectively, after controlling for key biotic and abiotic factors (forest amount, precipitation, time elapsed since restoration started, and past disturbance). Available biodiversity data strongly emphasize ecological metrics of abundance and richness, both of which take orders of magnitude of time less to achieve restoration success than species similarity and composition. These findings challenge the widely held notion that natural regrowth forests hold low conservation value and that ecological restoration strategies should favor active restoration. The notion that active restoration achieves greater restoration success than natural regeneration may have arisen due to the lack of controlled biotic and abiotic factors. In fact, we did not find any difference between active restoration and natural regeneration outcomes for vegetation structure without controlling for these factors. Future policy priorities should align the identified patterns of ecological conditions where each restoration approach is more successful and compatible with socio-economic incentives for tropical forest restoration.

S59.03 - Geographical variability of effectiveness of spontaneous succession as a restoration tool

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Passive restoration, i.e. using spontaneous succession to reach a restoration target, has been recently discussed rather often. But there is still the lack of comprehensive reviews evaluating success of passive restoration over a broader scales. I asked, what is the geographical variability of the direction of spontaneous succession towards the potential natural vegetation (PNV) which usually represents a desired endpoint. Successions running in abandoned fields and in various mining sites were evaluated in details. Full recovery, partial recovery, and no recovery of PNV were assessed based on the reviewed studies. The respective analyses considered particular biomes of the world and the latitude.

Because species richness generally declines with increasing latitude, we can expect an increasing probability that PNV is reached going to the higher latitude considering a neutral model. However, it appeared the lowest success of spontaneous succession to reach PNV in the Mediterranean type of ecosystems. Thus, a J-shape curve is the reasonable model. Regarding the particular biomes, recovery of PNV usually takes longer in forests and shrublands than in grasslands and deserts; non-native species are most likely to alter succession in mid-latitudes.

Other large-scale comparative analyses of the success or failure of spontaneous succession to reach restoration targets are desired.

060 Restoration planning in Brazil: setting priorities for tropical forest

060.01 - Restoration Opportunities Assessment in the South Paraíba watershed, São Paulo State, Brazil

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Restoration Opportunity Assessment Methodology (ROAM) has been applied in several countries to identify restoration opportunities and to leverage large-scale Forest Landscape Restoration (FLR) programs. This methodology started to be applied in the Paraíba do Sul River Valley, São Paulo State, in December 2015, convening key stakeholders to define the motivational factors to develop a FLR program in the region. A series of 5 workshops were organized to identify the key factors to unlock a FLR program in the region. The main motivators identified by the group of participants were: a) soil loss reduction; b) water infiltration increase and c) increasing of income for small land holders. GIS analyses crossed data about Gross Domestic Product, land use cost, legal compliance demand, high sedimentation delivery areas and high water infiltration zones to identify regions where these factors were most expressed. Return of investment analysis were conducted to assess the different typologies of restoration, agroforest and forestry to allocate those typologies on the landscape. The governance structure was implemented to help to identify the best data available, to validate the obtained results and to help establish ownership about the generated results. The final results of estimated cost of the FLR program and the gains in term of water yield, GDP and number of jobs are discussed.

060.02 - Mapping priority areas for compensation of Legal Reserve in the State of São Paulo

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Implementation of environmental laws in general, and specifically the Brazilian “New Forest Code”, due to its complexity and the sectorial disputes involved (environmentalists, farmers, legislators), must be supported by consistent technical support generated with solid scientific knowledge. Research specifically organized to support the implementation of this law can assist the executive power in public consultations and dialogues with various sectors of society, strengthening the technical basis of the discussions and providing credibility, given its neutrality of interest. The largest source of dispute in the implementation of the “New Forest Code” in the State of São Paulo is the regularization of Legal Reserves (RL), which involves the definition of areas of consolidated use, possibility of restoration in areas of low agricultural ability, possibility of compensation outside property limits, Environmental Reserve Quota (CRA) and purchase of other properties with remaining natural cover. Considering that the RL compensation mechanism via the market for CRA should prevail due to the lower cost and the large number of areas that can be issued CRA, the location of these areas and the prioritization for allocation of compensation according to ecological, hydrological, social and economic aspects, are pressing demands to provide public managers with a consistent database for public consultation of areas available for compensation. We present here a scientific proposal for mapping priority areas for compensation of Legal Reserve that could contribute as a methodology for the state’s development and implementation of the New Forest Code.

060.03 - Landscape partnerships: Assessing restoration opportunities within the southern Atlantic Forest Landscape of Brazil

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The Landscape Partnerships is a project which the main objective is to identify and promote restoration opportunities within the Southern Atlantic Forest. We identified opportunities for forest restoration looking at two components: the Brazilian Forest Code and Landscape Perception. For the Forest Code, we mapped 67.000 ha within 15 watersheds in the Serra do Itajaí National Park buffer zone and identified areas that must be restored to be in compliance with the law. For the Landscape Perception, we interviewed 190 landowners in order to understand their willingness to restore and conserve their lands. We assessed opportunity areas to restore by overlapping the two components in GIS. By identifying these areas, we engaged the municipalities, state government, NGOs, universities and landowners to implement restoration actions in the region. We will promote several activities regarding restoration within the identified areas. One of the activity is to restore two model properties according to the Forest Code requirements as an example to other landowners. Besides that, we will deliver 16 workshops about restoration and sustainability to at least 200 young students to directly inspire the next generation and undirectedly inspire their parents. We will also continue the engagement with key stakeholders to encourage other restoration actions. The outputs from the Landscape Partnerships project will increase the legal compliance with the Forest Code and improve the Serra do Itajaí National Park resilience and Atlantic Forest conservation.

060.04 - Planning for conservation and restoration under climate and land use change in the Brazilian Atlantic Forest

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We aimed to propose priority sites for conservation and restoration of woody plants under diverse scenarios, considering socio-economic costs, presence of protected areas, and distribution of forest remnants. We used ecological niche modeling to estimate geographic distributions for 2255 species under current and future climate scenarios, which we analyzed in relation to land-use projections, forest remnants, and socioeconomic variables. We identified spatial priorities that complement the current network of protected areas under three different scenarios: (1) conservation of existing forest remnants only; (2) conservation of remnants followed by restoration of degraded habitat; and (3) unconstrained actions, in which management location is not defined a priori. We compared our results under different levels of land protection, with targets of 10, 17, and 20% of the Atlantic Forest extent. Current forest remnants cover only 12% of the Atlantic Forest, so targets of 17% and 20% were achieved only through active restoration. Targets of 17% and 20% captured most species, and represented on average 26-34% of species' distributions. The spatial pattern of degraded habitats negatively affected representation of biodiversity and implied higher costs and reduced efficiency of planning. We did not observe major differences between prioritizations based on contrasting climate change scenarios. Protection of forest remnants alone will not suffice to safeguard woody plant species; therefore, restoration actions are urgently needed in the Atlantic Forest. With integrated management actions and multi-criterion nationwide planning, reaching the 17% of land protection of Aichi biodiversity targets will constitute an important step towards protecting Atlantic Forest biodiversity.

060.05 - Landscape analysis and land registry data as a basis to prioritizing restoration of private areas environmental liabilities in the Brazilian Amazon

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Increased pressure for the effective implementation of the Brazilian Forest Code may represent a major opportunity to reestablish the connectivity between private forest fragments or among these and protected areas and indigenous lands in the Amazon region. Per the Forest Code 80% of each rural property (the "legal reserve" or LR), including all areas along watercourses, around

springs and on steep slopes (known as “permanent preservation areas” or PPA), must be kept under native forest cover. If deforested in excess, these areas need to be restored. We used landscape metrics to analyze the fragmentation condition in a major deforestation frontier, São Félix do Xingu, an 8.4 million-hectare municipality in the Eastern Amazon region, with 5 million hectares of indigenous lands and strictly protected areas. We then combined results of the landscape analysis to properties’ data from the Rural Environmental Registry system. This registry is a first step in fulfilling the Forest Code through spatial information about farms perimeter, PPA and land use. Our analyses indicated that most of the observed forest fragments occupied an area smaller than 50 hectares and the distances between them generally varied from 10 to 500 meters. These results were key in the evaluation of the natural regeneration potential of deforested areas, and in the identification of the most effective areas for promoting landscape connectivity. This information can be the basis to prioritizing the restoration of legal reserves, ensuring that the recovery of environmental liabilities is considered in a context of territorial planning.

S61 From Theory to Action: Implementing new international standards for the practice of ecological restoration

Organizer: Bethanie Walder

S61.01 - Operationalizing SER's International Standards: Utilizing the standards to achieve international climate and biodiversity targets

BETHANIE WALDER

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Ecological restoration is increasingly promoted and funded as an important solution for environmental degradation and climate change throughout the world. However, international agreement on what constitutes restoration does not exist, nor does systematic oversight of restoration projects. Restoration may only achieve limited progress toward international targets (e.g. Aichi Targets under the Convention on Biological Diversity, reforestation targets under the Bonn Challenge). When sole ecosystem services (e.g. carbon sequestration, flood control, wood products), drive the “restoration” agenda, the results may not be as ecologically restorative as intended. SER's International Standards for the Practice of Ecological Restoration provide a framework for assessing and promoting ecologically- and socially-sound restoration that achieves multiple benefits. The Standards create a framework for improving the biodiversity outcomes of climate and reforestation initiatives, and for implementing multi-faceted, ecologically-based restoration programs throughout the world. This presentation will discuss opportunities to engage governmental and non-governmental organizations, funders, and industry to incorporate the Standards into their ongoing restoration programs, including at the planning, implementation, and monitoring phases. As part of that process, SER is soliciting feedback on the Standards from a variety of stakeholders globally, in preparation for future revisions to this “living document.” Integrating SER's scientifically- and socially-sound standards into international agreements to achieve reforestation, restoration and climate targets will help ensure that global commitments and financial investments for restoration achieve desired ecological and social goals.

S61.02 - Optimizing integrated broadscale environmental repair using the SER Standards' spectrum of full and partial recovery

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SER's 'International Standards for the Practice of Ecological Restoration' provide a number of clarifications about what exactly is meant by ecological restoration in a rapidly changing world. One important clarification is the degree of recovery aimed for if a project is to be classed as a restoration activity. A project with goals of full recovery or partial recovery can be considered a restoration activity under the Standards if the goals represent 'full recovery insofar as possible' relative an ecologically appropriate local native reference ecosystem. Implicit in the phrase 'full recovery insofar as possible' is an expectation that the ultimate level of similarity with the reference should be at least substantial; which is interpreted by the Standards as meaning substantial recovery of ecosystem functionality and native biota, not functionality alone. Nonetheless, this inclusion of 'partial recovery' accommodates a wide range of real life constraints and offers potential for restoration principles to be applied to semi-natural environments that will remain permanently utilized. Thus the restoration framework can accommodate all efforts that focus on substantially improving a site or habitat's similarity with an appropriate native reference ecosystem even if the ecosystems must remain in a 'hybrid' condition somewhere between 'fully intact' and 'fully transformed'; optimizing potential for broad scale and biodiverse environmental repair including and beyond conservation reserves.

S61.03 - SER International standards create regulatory opportunities for biodiverse ecosystem repair

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Estimated at a trillion dollar industry, it is surprising to many that there has never been a universally acknowledged standard for the practice of rehabilitating damaged or depleted landscapes. For industries involved in impacts in natural environments that include infrastructure developments, resource industries, urban developers or those that need to adopt restoration as offsets for development, the lack of clear and accepted guidance statements have meant that site to site and over time, the quality, expectations and outcomes for restoration have often resulted in sub-standard restoration outcomes. For regulatory bodies setting the 'bar' on the social licence to develop through the newly launched International Standards provide the first, and most consistent means to define, understand outcomes and, accept a level of completion on a restoration outcome. The implications of this new and important tool for guiding innovation and creativity in the restoration sector will be discussed and placed into the context of how regulatory agencies can use the Standards for improving global capacity in restoration.

S61.04 - Applying the International Standards to a large-scale forest rehabilitation program: Opportunities to improve biodiversity outcomes in China's Grain-for-Green Program

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China's Grain-for-Green Program (GFGP) is the world's largest reforestation scheme. Here we present our research on the biodiversity implications of GFGP, and apply the International Standards of Ecological Restoration developed by the Society for Ecological Restoration (hereafter SER standards) to evaluate the effectiveness of GFGP as a possible ecological restoration program. Through a nationwide assessment of the tree composition of GFGP forests, we find that across China, GFGP forests are overwhelmingly monocultures and compositionally simple mixed forests. Focusing on birds and bees and combining biodiversity and economic analyses in south-central Sichuan Province, we find that GFGP reforestation entails some gains and losses in species richness and considerable compositional turnover for birds, and overwhelming declines for bees. Moreover, all modes of reforestation fall well short of restoring bird and bee diversity to levels approximating those of the land cover originally cleared to create the cropland now being reforested by GFGP. However, even within existing modes of reforestation, GFGP has considerable under-realized potential to achieve biodiversity gains by planting mixed forests instead of monocultures; doing so is unlikely to entail opportunity costs or pose unforeseen economic risks. Based on these findings, and given the overall pattern of forest reestablishment and management under GFGP and the policy as well as socioeconomic context, GFGP should be assigned a 1- or 2-star ranking on the 5-star evaluation system of SER standards. In addition, in its current form, GFGP should be considered an ecological rehabilitation program rather than an ecological restoration program.

S61.05 - A proposal to apply the international standards for the practice of ecological restoration in coral reefs in Mexico

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The increasing degradation of coastal and marine ecosystems requires the implementation of ecological restoration to recover the structure and function of damaged environments, and then the environmental services they provide. In Mexico, a coral reef restoration program is carried out since 2012. Active restorations have been done at four reef areas through sowing corals. Techniques were designed for the production of coral colonies (clonal propagation and sexual reproduction), colony transplant and the establishment of a coral nursery. As a result, coral cover (biomass) increased, greater abundance of reef building made a switch of dominant species, environmental heterogeneity increased, and fish fauna improved in richness and density. Also, reproduction activity was detected in coral colonies planted at the beginning of the project. These elements contribute to recov-

er the ecological functions towards a resilient ecosystem. Recently, at the thirteenth meeting of the Conference of the parties (COP13) to the Convention on Biological Diversity (Cancun, Mexico, December 2016) some political agreements for coral reef restoration were established. The government of Quintana Roo State supports The National Fisheries Institute (INAPESCA) and The National Commission on Natural Protected Areas (CONANP) to restore 20% of the Mexican Barrier Reef (54 km). This agrees with the goals of the Sustainability Agreement signed by the governments of the 3 states of the Yucatan Peninsula (ASPY 2030). One of the goals in this project is to apply SER's International Standards for the Practice of Ecological Restoration, and to adapt the principles and concepts to the marine environmental.

S61.06 - Incorporating the Standards into the Convention on Biological Diversity's Short-term Action Plan on Ecosystem Restoration.

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The International Standards were launched at the Convention on Biological Diversity's 13th Conference of the Parties (CBD COP) in Cancún, Mexico in December 2016. This occasion was chosen in recognition of the anticipated adoption of a Short-term Action Plan on Ecosystem Restoration. The short-term action plan aims to promote the restoration of a spectrum of degraded ecosystems including urban areas to stem the loss of biodiversity, while ensuring that ecosystem resilience, improved ecosystem services, improved human well-being, and other benefits are achieved. It is meant to assist the Parties to the Convention, as well as other organizations, in both accelerating and upscaling restoration. There are four key activities of the plan: (1) assessment and prioritization of restoration opportunities, (2) improving the institutional enabling environment to ensure appropriate legal, policy, and financial structures are supportive of restoration, (3) adequate planning and implementation of restoration, and (4) establishing monitoring for evaluation of restoration, adaptive management, and sharing of results. I will frame how SER's International Standards both support and amplify the CBD's Short-term Action Plan on Ecosystem Restoration and other related efforts.

062.01 - Sampling reference forests on different soils to drive tree species selection to restore the riparian forests of Itaipu reservoir

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Atlantic Forest is globally recognized by its rich biodiversity and because it is among the most devastated and seriously threatened forests on Earth. These threats are extraordinary in Paraguay, where it has been rapidly replaced by agriculture and pastures. Forest restoration is, therefore, urgent and depends on knowledge about the rare forests remaining to drive species selection. Considering that forests occurring in distinct soil types can have different sets of species, we carried out extensive samplings in Biological Reserves owned by Itaipu Binacional in Paraguay, aimed at the indication of species to restore the riparian forests around the lake. Permanent plots of 1.0 ha were sampled in six different sites in those reserves, and trees from 10 cm DBH were measured. Two plots were located in Ultisols and four in Oxisols. A total of 127 species (86 genera and 40 families) were recorded. According to the successional groups, the species were categorized as 20 late successional, 8 heliophytes, 42 pioneers, 39 secondaries, 3 shade tolerant species and 15 not determined. All plots have high tree diversity. The highest value for the Shannon diversity index (H') was 3.728 for Tatí Yupí, and the lowest was Itabó 02 with 3.036. In spite of the soil differences, all plots can be considered floristically similar (minimum Jaccard index of 0.37). From the species sampled, we recommend 90 species to be widely used in restoration along the margins of the Itaipu reservoir.

062 Species selection to maximize restoration success

062.02 - Development of a method to validate the performance of riparian forest species regarding to their ecological potential and use for restoration

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The objective was to validate the performance of riparian forests species through the aggregation of the ecological potential and their uses for ecological restoration. The experiments were implemented in 2011 in three disturbed areas of central Brazil. We used seedlings of 21 native species. The methodology for validation was based on three aspects: performance of species (growth and survival); ecological potential for restorability (EPR): category sucessional, fruit type, ability to attract fauna and crown projection, which ranged from 1 to 9; and the potential to use (PU): the possibilities of uses by species, which ranged from 1 to 20 (bibliographic data). The sum of EPR + PU generated the potential of restauration and use of the species (PRU). The values of the PRU were categorized: low (2 to 8), medium (9 to 16) and high (17 to 29). The results of aggregate performance to PRU validated and classified the species: 1) 8 species as highly recommended (high performance + high or medium PRU); 2) 8 species recommended (medium performance + high or medium PRU); 3) 4 species recommended with restrictions (medium performance + medium or low PRU) and 4) 1 species little as recommended (low performance + medium PRU). The application of PRU can be an important tool to assist in the choice of species for restoration and it can be use in the valuation process of the species.

062.03 - A functional trait analysis for drought and fire pressures for tree species selection for restoration in a tropical dry forest of Costa Rica

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The tropical dry forest, the most degraded Mesoamerican forest, requires clever decisions about tree selection for restoration purposes, which are more critical in the face of climate variability. We measured functional traits of trees in the Palo Verde, Costa Rica during 2015 and 2016 in order to obtain a sensibility classification of tree species after ranking them according to the values of functional traits that identify water stress and fire tolerances, which are the main climatic and anthropogenic dry forest stressors. We measured stem hydraulic conductivity, xylem-specific density, leaf mass area (SLA), thickness, wood volume and density on 25 dominant tree species; On 46 tree species, we measured the following fire-related traits: tree diameter, bark thickness, relative bark thickness, amount, thickness and water content of leaf litter, and some litter flammability parameters obtained from burning tests. The three evergreen species showed the highest degree of drought resistance. Smaller tree diameters and reduced bark thickness were related to greater susceptibility to fire. Flammability tests provided a ranking of tree species where large, thin leaf species with larger SLA burn more easily, with faster and greater intensity than small, thick leaves with small SLA, which take longer to start the combustion and with less intensity. Taken together, functional traits provided an initial tree species list to choose to plant for restoration and to identify areas with greater risk of drought and fire. Further studies must consider other traits to obtain a comprehensive list, such as growth rate, dispersal, and establishment success.

062.04 - Ecological and economic benefits of environmental restoration using the native grass variety in China

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The degradation of grassland is a serious ecological problem in Northern China, and the desertification land areas are about 3 billion 900 million acres. The desertification land is arid, barren and sparsely vegetated, which increases the occurrence of sand and dust weather, and the economy of these regions is backward and the people have been struggling on low incomes. *Leymus chinensis* (Trin.) Tzvel (also known as sheepgrass) is a native, perennial forage grass in China and Mongolia Steppe, with a vigorous cross-walk rhizome system that facilitates the absorption of moisture under high salt stress and drought conditions. So sheepgrass plays an important role in soil stabilization, re-establishment and improvement of degraded grassland, as well as ecology restoration. We have collected and evaluated thousands of wild sheepgrass germplasm, and selected several new varieties such as Zhongke No. 1, 2, 3. The field trials have been carried out in degraded grassland, saline-alkali soil, and sandy soil. The results showed that the vegetation coverage rate was reached to 95% in the third year, while only 25% at the beginning of the restoration works. Therefore, development of the native species could effectively improve the degraded land, restoration of ecological environment, and promote the development of economy which will make a very important practical significance on achieving an ecological and economic regulation.

062.05 - The use of vegetation classification analysis and indicator species analysis for restoration goals planning of páramo and high andean forest in Ciudad Bolívar (Bogotá-Colombia)

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The study was made in rural areas of Ciudad Bolívar, at the south of Bogotá City. The objective was to establish a guideline for planning restoration goals using the results of vegetation classification analysis and indicator species analysis. A floristic classification of 142 plots was performed to identify floristic communities through UPGMA grouping method, together with the Morisita index as similarity distance. Another classification was performed using a dichotomous key for páramo's vegetation structural types, stated previously for Los Nevados National Park. The groups of both classifications were crossed in a floristic vs. structure matrix. Another analysis was performed to establish the indicator species of the crossover groups. 18 floristic communities and 11 structural types were found. The crossing of both classifications shows that each floristic community can present several structural configurations with different level of complexity (eg, number of strata and woody biomass). There are 46 vegetation groups in total, each with 2 to 3 indicator species, sometimes different from those in their corresponding community. The structural types of interest for the restoration of rangelands and crop zones are those where shrubs predominate, mainly because they increase structural complexity in high andean forest and subpáramo where they have species able to colonize these kind of areas, and in the páramo where they represent relics of woody vegetation mostly eliminated by disturbances. Three scenarios of restoration goals planning are proposed, in which indicator species are selected as fast-growing pioneer and variables of structural complexity are stated as indicators of monitoring.

062.06 - Botanising vs restoration: One is hot and one is not but we need them both

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Exploration and the documentation of plant diversity was once a highly-revered career, employing only a few elite scientists who travelled the world collecting, recording and classifying what they found. In recent times, botany has become a less desirable career path, horticulture is a badly paid profession and the number of people training in this field is reducing world over. The interest in restoration on the other hand, has grown greatly in recent years. In the case of forest restoration, large pledges have been made and NGOs, government and the private sector are all taking up a role in restoration. However, in many

cases restoration lacks botanical input. Species planted are not appropriate and there is a lack of aftercare following planting. Botanic gardens and their staff hold collection records, species knowledge, scientific, horticultural and conservation skills: key ingredients for planning and implementing restoration that are not commonly found in other sectors. Members of the Ecological Restoration Alliance of Botanic Gardens (ERA) manage restoration sites across six continents that demonstrate the value of involving botanical and horticultural expertise in restoration. New tools produced by the network support restoration, including GlobalTreeSearch: a list of the world's tree species with country-level distribution information which can guide species selection. This presentation will demonstrate that botanical knowledge and horticultural skills are more relevant than ever. Case studies will be shared, and tools and opportunities highlighted for other sectors to collaborate with and harness the knowledge of the botanic garden sector to improve forest restoration results.

S63 Institutional arrangements fostered by the Brazilian Forest Service (SFB) to support initiatives for restoration of rural degraded areas in Brazil. - Subsection 1

Organizer: Janaina de Almeida Rocha

S63.01 - Brazilian Forest Law and federative dialogue for implementation between Brazilian Forest Service and States Governments

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The Rural Environmental Registry – CAR consists of a mandatory landholding registration instrument, created in order to establish a database to monitor and control the use and conservation of native vegetation; to support environmental and economic planning; and to back strategies to combat deforestation at national level. Analysis of the information regarding landholding registration in CAR, which, by February 2017, reached 3.99 million records, reflecting an area of 402,782,597 hectares, shows that the Environmental Compliance Programs (PRA) and their benefits in fact represent incentives to registration seeking law compliance. In addition, most of state administrations have decided to use the SICAR technological package, while the ones that developed their own information systems have been effectively integrated to SICAR, with positive effects towards the standardization of compliance procedures, and the consolidation of the registry and its database. This presentation focus on the Brazilian Forest Law and on the federative dialogue between the representatives of the Brazilian Forest Service and state administrations, which has been crucial to guarantee the results accomplished so far, both at state and national levels.

S63.02 - Governmental promotion of forestry – the challenges. Brazilian Forest Service contributions to the strategy to Environmental Regularization of rural properties with ecosystem restoration.

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The Brazilian forest code and the environmental regularization programs established by this law have made the restoration of native forests more evident. However, while legal norms have evolved to clarify the roles of governments and landowners, the fragility of the productive chain for the restoration of native vegetation, as well as the tools to monitor the effectiveness of this restoration, are the major challenges.

The Brazilian Forest Service (SFB) works in partnership with research institutions and universities to improve and disseminate technology for field activities and tools to monitor restoration actions. Implementation of projects focused on small farmers and traditional communities are supported by financial and technical cooperation with the FIP (World Bank) and German Government (BMUc, GIZ and KfW).

The strategy adopted by the Forest Promotion and Inclusion Department of the SFB seeks to make it possible to restore the vegetation by innovating in public purchases, fiscal incentives and the local capacity building involving training, technology and strengthening of the forest restoration chain through the establishment of Sustainable Forest Development Centers (CDFs). These Centers are specialized in forest management and the silviculture of native species.

Acting as warehouses for the production of seeds and inputs for the propagation of native vegetation, the CDFs have as its principle the strengthening of Brazilian traditional communities, which are spread through territories equivalent to 53% of public forests with conserved native vegetation. The Centers also identify, from the Rural Environmental Registry, the rural areas that require restoration of the native vegetation, according to the law.

S63.03 - The Environmental Rural Registry and the mapping of areas to be restored in rural properties in Brazil

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The Rural Environmental Registry – CAR consists of a mandatory landholding registration instrument, created in order to establish a database to monitor and control the use and the conservation of native vegetation; to support environmental and economic planning; and to back deforestation combat strategies at national level. Declared data include landowner identification and information about the property, such as the geolocation of: the perimeter of rural property, areas with remnants of native vegetation, permanent protected areas, Legal Reserve, and the converted areas. Amongst the contributions that the CAR information system (SICAR) can provide to landholding analysis, special reference should be made to the usage of satellite images, continuous land use mapping, and automatic routines that may indicate the permanent protected areas or the Legal Reserve – RL in equivalent, inferior or superior quantity in relation to the references established by the Law nº 12.651/2012, as well as the areas of native vegetation which must be restored or compensated in order to guarantee law compliance. The presentation will include a chronological contextualization of compliance procedures, before and after the approval of the new forest code, and focus on SICAR's specific attributes that were designed and developed in order to facilitate the evaluation of the landholding compliance status.

S63.04 - National Fund for Forestry Development: Operational model and partnership framework to foster forestry public calls

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The National Forestry Development Fund (FNDF) was instituted by the Law no 11.284/2006 and regulated by the Decree no 7.167/2010. It is a public financial fund whose aim to foster the development of sustainable forestry activities in Brazil and promote technological innovation in the forestry sector, with non-reimbursable resources. Since its regulation, the FNDF had 19 public calls, a public procurement as an executive fund and a public procurement as a co-executive fund, contemplating four Brazilian biomes – Amazônia, Caatinga, Cerrado (Savanna) and Mata Atlântica (Atlantic Forest). The FNDF themes include such as supporting seeds and seedlings production; sustainable forestry management; family and community forestry management; research and fostering of technical assistance initiatives in forestry; training and value adding in the chain of production of timber and non-timber forestry products. The main public benefited by those public calls were family farmers, traditional communities and technical assistance and rural extension technicians working in the forestry sector. These 21 public calls resulted in 229 selected projects. A total of 146 projects signed contracts and are underway. Caatinga biome excels as the biome with the largest number of contracted projects with a total of 107 projects between 2010 and 2016. This effort represents 73% of all contracts financed by the FNDF and has as its main investor the National Fund for Climate Change (FNMC/MMA), a financial line for adaptation to climate change, receiving a total of R\$ 12 million, which represents 67% of financial resources spent by the FNDF.

S63.05 - Funding the restoration of permanent preservation areas for water production – a Call for Proposals by Brazil's National Environmental Fund

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In September of 2015, Brazil's National Environmental Fund (FNMA) published the call for proposals 01/2015 – Restoration of Permanent Preservation Areas for Water Production. The objective of the call for proposals was to select forest restoration projects in watershed areas that contribute directly or indirectly to water supply in 18 Brazilian metropolitan regions with critical levels of hydric deficit.

The call for proposals pools resources from six funds: FNMA, Brazil's Climate Fund, the National Forest Development Fund, The Social-Environmental Fund of Brazil's Caixa Bank, The Diffuse Rights Defense Fund, and the National Water Agency, with total investment of 45 million Reais (approximately 15 million US dollars).

Eighteen projects were selected for funding by FNMA's board. The projects predict investments of up to 3 million Reais over a period of four years for forest restoration of areas bordering springs and rivers. The activities that will be carried out include mobilizing the beneficiary populations (small farmers), forest restoration with native seeds and seedlings, and the production of an environmental services payment plan for the region. The area that will be restored by the 18 projects is 5,650 hectares. The projects are located in the Brazilian states of Bahia, Rio Grande do Norte, Goias, Espirito Santo, Sao Paulo, Minas Gerais, Rio de Janeiro, Santa Catarina, Rio Grande do Sul, as well as the Federal District. The projects are beginning their activities during the first semestre of 2017.

S66 Frameworks and gaps: Cross-referencing the policy, purpose, standards, ecological theory and practical research needs for effective restoration

Organizer: Ben Miller

S66.01 - Examining the Standards from the perspective of policy, process and the multiple purposes of restoration

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A new policy tool enables practitioners to differentiate restoration objectives and identify complex links between rationales and assessment. Applying this tool to the new Standards for Ecological Restoration reveals gaps in how we consider restoration. Evaluation criteria of success need to include not only social and economic markers, but recognize that restoration is driven by multiple rationales, often in the same project, and where preference dynamics exist. Uncovering the links between goal setting and choice of instruments and actions supports evaluation that is more complete. In addition, notions of success need to be linked to both output legitimacy (what results were achieved) and process (how decision are made and by whom, such as through more participatory and deliberative decision-making). Legitimacy is grounded on both instrumental and normative rationales. A deeper challenge comes from the need to go beyond the assumption that restoration policy or projects are linear, rational endeavors with clear, specified and non-contradictory objectives, which can accordingly be evaluated against pre-determined benchmarks. Here, evaluation has to take account of both structured and reflexive agency. Structured agency speaks to the knowledge and capability among restoration policy makers and practitioners, acting with bounded rationality, through routine (professional) behaviour, and within the context of institutional embeddedness. However, there are also unknown preferences and unintended consequences. The concept of reflexive agency helps evaluation take account of non-linearity, such as those arising from unintended consequences.

S66.02 - The practical science needed for successful restoration

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Despite a plethora of practical restoration work on the ground and of restoration research within academia, there still exists a gap between what practitioners find important and what restoration scientists focus on in their research. Miller et al. (2016) have correctly highlighted this fact, and the lack of existence of a concerted framework that specifically addresses the practical science needed for successful restoration. Whilst we know which ecological theory is of most relevance to restoration (succession and assembly, dispersal and microsite limitation, food web dynamics), the outcomes of research in complex ecosystems are never simple recipes, and the key questions asked by practitioners can vary quite strongly from the foci of researchers. The case I make with this presentation is that there are strong overlaps between the practical and the scientific approaches, but that clearer, more frequent communication is necessary. Recent groundbreaking work is paving a possible successful way forward given good communication: how food web complexity and linkages develop over time; which plant species provide the highest number of beneficial links to organisms at higher (and lower!) trophic levels, how timing of planting/sowing can significantly influence restoration success, how to reinstate ecosystem functioning and make sure systems are resilient in the face of climate change, increasing carbon storage as well as providing multiple other ecosystem services, top-down or bottom up control (related to reinstating key carnivores, or key grazers). A recent German-speaking network of restoration actors (“Netzwerk Renaturierung”) founded at the SER Europe meeting in Freising in 2016 aims to actively address this gap between what practice needs and what science can deliver.

S66.03 - The structure of restoration ecology: Science, policy, standards and practice

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The urgent need for Ecological Restoration at local and global scales is recognised in mainstream policy and awareness. Discussion about definitions, standards and protocols may seem a distraction, yet very often ambiguity, lax interpretation and structural gaps in the thinking of the restoration community may be leading to perverse outcomes. We say restoration is part of a solution, but how we communicate it could be part a problem.

Ecological Restoration now has a number of formal structural elements. The venerable Primer's process-based definition and '9 attributes' has long been an important guide. Subsequent critical analyses of the discipline have identified: the limited range of assessment metrics employed; geographic, taxonomic and procedural biases in the science; widespread failure of outcomes relative to expectations; and questioned the role of science. Recently the International Standards; accreditation for practitioners; a Practical Science Framework outlining a research agenda to improve practical outcomes; critical reviews of restoration policy and motivations, the role of ecological theory, and even the definition of restoration have abruptly crystallised a complete but untested structure for ecological restoration.

We examine this structure to reveal failings among our definitions, assumptions, communication, research initiation and practices around restoration. While typically harmless, these gaps do have the ability to significantly undermine our capacity to properly identify costs and benefits of strategic policy alternatives, and communicate of the case for investment in research to improve practice. This conference highlights the need to address the Science-Practice gap, understanding these structures and constraints might help bridge this gap.

S66.04 - Identifying and communicating the practical science needed to meet the challenge of delivering biodiverse restoration: A case study of restoration science within a mining context

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With current global resource footprints for individual mining companies exceeding 1,000's km², extreme pressures on biodiversity have emerged. Despite ecosystem restoration offering an economically viable solution for, and providing a proactive and critical role, in increasing global biodiversity values, and despite significant investment and increasing levels of environmental compliance, ecosystem restoration *sensu stricto* (matching the diversity, structure, dynamics and function of the reference state) has not been achieved.

A significant issue is that restoration in the resource sector has traditionally been viewed simplistically - more akin to a gardening exercise with both regulators and industry often having limited understanding of the science requisites for effective ecosystem restoration in fields such as: genetic provenance, seed supply and enablement, soil science, ecophysiology and growth medium development (particularly for complex post-mining substrates such as tailings materials). Furthermore a gap between the immediate needs of restoration practitioners and the outputs of restoration science often limits the effectiveness of restoration programs.

If research is failing to address the most pertinent issues required, then the practice and policy required to protect biodiversity in the context of expanding resource extraction will also fail. Here we develop a comprehensive framework for the practical biophysical science needed for post-mining restoration. While understanding developed for one site, region or biome may not directly apply to others, the broad framework of questions does. This presentation outlines the necessary research in five themes: 1) Setting targets and planning for success, 2) Sourcing biological material, 3) Optimizing establishment, 4) Facilitating growth and survival, and 5) Restoring resilience, sustainability and landscape integration to assist restoration practitioners and scientists to identify knowledge gaps and develop strategic research focused on applied outcome.

S67 Is Assisted Migration Appropriate for Restoration of Biodiversity and Ecosystem Function?

Organizer: Stephen Murphy

S67.01 - Long term experimental evidence of benefits and risks of assisted migration in restoration ecology

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There are few long term studies that can address the issues and provide evidence regarding risks and benefits of assisted migration in restoration ecology. In 1989, several plants near their northern limit of their contiguous range were transplanted from privately owned woodlots in the Mixedwoods Plains ecozone in eastern Ontario to privately owned woodlots 20 km north where the "Frontenac Axis" of the Boreal ecozone is present. This transitional area is characterized by a change from limestone to granite bedrock as well as a temperature and precipitation gradient related to the influence of Lake Ontario on the Mixedwoods Plain ecozone vs. the more isolated areas of the Boreal ecozone. It is unusual because of the stark juxtaposition of the two ecozones. I transplanted 500 genets of each of *Podophyllum peltatum*, *Hepatica nobilis* var. *obtusa*, *Sanguinaria canadensis*, and *Erythronium americanum*. In this transition zone, the plants were largely restricted to the Mixedwoods Plains portion. After 25 years, the plants have thrived in areas where they should have been stunted as they are plastic enough to adapt to shallower soil and have been assisted not only by transplanting but by temperature shifts and northerly range expansion of several of their pollinators. The plants normally dominant in the Boreal understory have declined – but this is true of areas that were control, hence it is likely the risk to them was not the assisted migration itself but anthropogenic climate change.

S67.02 - The sea comes marching in: Assisted plant migration through the microbial community landscape

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Sea level rise threatens the stability of coastal wetlands globally, but is a particular threat to wetlands where the rate of relative sea level rise, such as those along the Gulf of Mexico coast. Anticipatory restoration via assisted plant migration is being explored to increase the resilience of these marshes; however, little is known about how these efforts may influence, or be influenced by, the microbial landscape through which plants are moved. Here we compare 16S-rRNA based microbial community composition and association networks from four replicate marsh-pine island complexes to examine shifts in the microbial landscape across the four vegetation zones (pine forest, fresh marsh, brackish marsh, and salt marsh) typical of these ecosystems. Across these zones, we observed marked taxonomic differences in microbial community composition, with nearly distinct communities occurring within each vegetation zone. Microbial community composition was more tightly linked with edaphic factors than it was to plant community composition. Overall, taxa had a greater number and strength of significant interactions towards the lower end of the gradient, possibly a reflection of the strength of habitat filtering in these systems. Given the dominant effect of edaphic factors on microbial community composition, these communities are unlikely to experience large changes in composition in response to assisted migration; however, as plants are moved up a gradient in advance of rising seas, they are likely to encounter novel microbial taxa with unknown effects on their successful colonization, competitive abilities, and growth.

S67.03 - From Species Reintroductions to Assisted Migration: A continuum of conservation strategies

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Climate change threatens between a third to one half of global plant taxa. Although changing environmental conditions are nothing new, in the context of other human-mediated environmental changes the purposeful translocation of species to ensure their conservation is one solution. The idea of species translocation - or "assisting" their migration - is both alluring and repellent. Only a handful of studies have documented the success of the approach or veracity of the risk. Looking at both the restoration literature and the plant reintroduction literature provides insights into both the promises and pitfalls of translocating species as an adaptation strategy in the face of our changing climate. The practice of restoration and the implementation of assisted migration of rare plant species have different objectives and goals, however, both result in the translocation of species from their site of origin to a new one. It is the scale across which the movement of species occurs that is problematic.

S67.04 - Assisted migration in restoration and conservation of coastal ecosystems

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Low-lying coastlines are among the first ecosystems directly impacted by chronic sea level rise. Coastal species may cope with environmental changes over the short term but eventually they will be eliminated unless inland migration occurs. We hypothesized that inland migration of downslope species is impeded by upslope vegetation barriers. In 2011, we initiated a reciprocal transplant experiment to investigate the feasibility of upslope, assisted migration, with and without removal of standing vegetation. A transect was established at each of five stations along East Bay River, a tidal river ecosystem in northwest Florida. Each transect extended perpendicular to the river into upland habitat to include 1m, 2m, and 3m changes in relative elevation from the river's edge. Nine 2m x 2m plots were established haphazardly in each of the three elevation classes alongside each transect (n = 135). Three plots were assigned as controls and the remaining six for vegetation removal. In November 2011, 1350 individuals of four species that represent dominant vegetation zones were harvested. Each of the plots was divided into four 1m² subplots and randomly assigned to one of the four transplant species. Individuals were transplanted into the plots within 24 hours of being excavated. Surveys of plant condition were conducted 2012-2016. The dominant marsh species, *Cladium mariscus* and *Juncus roemerianus*, exhibited multi-year survival in plots spanning the estuarine and elevation gradients, including habitats that received prescribed burns. Assisted migration was most successful in where salinity stresses were reduced but freshwater flooding prevailed.

068 Water-related ecosystem services: policy and planning

068.01 - Vegetation association to groundwater depth and perspectives for restoration of shallow aquifers in the Great Basin, USA

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Groundwater development provides essential benefits for human health and economic growth. The challenge is to achieve these benefits while using the resource in a controlled and sustainable manner. In aquifer areas, where groundwater is used for human consumption and is shallow enough to support natural vegetation, it is important to understand the relationship between groundwater depth and plant species distribution. This study took place in Owens Valley, California, USA, in areas with depth to groundwater (DTG) from 0.3-4 m. This is an arid area dominated by typical cold desert Great Basin vegetation. Species frequency, cover and DTG were recorded along 67 transects distributed throughout the valley. Species distribution as related to DTG pointed to three main groups of species 1) shallow groundwater (DTG < 1.5 m) with *Juncus arcticus* and *Distichlis spicata* dominating, 2) medium groundwater (DTG 1.5-2.0 m) with *Atriplex torreyi*, *Leymus triticoides*, and *Ericameria nauseosa* dominating and 3) deep groundwater (DTG > 2 m) with *Sporobolus airoides*, *Sarcobatus vermiculatus* and *Artemisia tridentata* dominating. Shallow groundwater areas were clearly dominated by graminoids but medium and deep groundwater areas contained both grasses and shrubs. Although species distribution was related to DTG, variation in DTG was poorly related to plant cover or the condition of individual plant populations. Restoration efforts should be focused on maintaining the presence of plant species according to the typical DTG of their areas of distribution. However, the condition of the populations is probably more related to surface water (precipitation) than to the variation in DTG.

068.02 - The use of spatial predictions on ecosystem services in the planning of sustainable use of peatlands

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There is a need to optimize the use of peatlands to simultaneously reach the biodiversity, environmental goals and the economic needs. Besides raw material timber and peat, peatlands provide a variety of valuable services, such as biodiversity, C sequestration and hydrological control. High pressure is targeted to these ecosystems by e.g. forest, bioenergy and peat industries. In Finland, a country with the highest percentage cover of peatlands in the world (30% of total land area, almost 10 mill. ha), about 60% of peatland area has been drained for forestry. This had led to the degradation of biodiversity, environmental loading to watercourses, and emission of greenhouse gases (GHG). Since 20% of the drained peatland area does not produce enough timber to fulfil commercial purposes, restoration is one among many options for the use of these low-productive drained peatlands. I present the EU funded LIFEPeatLandUse project, in which we used empirical country-wide spatial data 1) to estimate and predict the impact of seven peatland uses (incl. restoration) on the biodiversity, GHG balances and environmental loading to watercourses, and 2) to numerically optimize cost efficient land uses so that benefits from biodiversity and ecosystem services are safeguarded. I will also demonstrate a multicriteria decision support tool that was piloted in a real land use planning case. The presentation shows that optimization of peatland uses can be made by state-of-the-art methods and tools developed by scientists. Continuous contact between stakeholders is needed throughout the process to fulfil the acceptability of the planning.

068.03 - Environmental governance of the Matanza-Riachuelo watershed during 1536-2016: Implications for restoration of hydrological functions in a mega-city (Buenos Aires, Argentina)

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Since the first European settlement in 1536, the fluvial dynamics of the Matanza-Riachuelo watershed has been subjected to uninterrupted and progressive modifications, contributing to current state of severe environmental and ecological degradation. The review of historical information allowed us to identify a large amount of society-driven events, including political decisions, which led to changes in hydrological functions. We elaborated a timeline of critical events and determined five major periods of degradation: (1) negligible (1536-1780), (2) low (1780-1870), (3) increasing from moderate to high (1870-1960), (4) severe (1960-2006), and (5) severe with legal goals of recovery (2006-current). In 2006, the Supreme Court became a key actor redefining the governance scenario for the watershed. Proximate and ultimate causes of degradation, inferred in this study from the chronology of events that led to changes in the watershed hydrology, include: (i) social disregard of the importance of fluvial processes and forms, and conceptualization of lowlands as “wastelands” or unproductive areas, (ii) absence of land planning as the base for territorial management decisions, (iii) breaches of existing regulations regarding land use, (iv) prevalence of economic productivity as the criterion to legitimate modifications of fluvial processes, and (v) absolute predominance of engineering approaches above environmentally integrated perspectives in flooding prevention. Our review of current trends in fluvial management, based on case studies from different regions of the world (Europe, USA, Latin America) provides a key starting point for planning restoration efforts focused on hydrological functions in highly urbanized watersheds.

068.04 - Natural Infrastructure for water in Brazil: How restoration can improve water quality

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One of the greatest strategic opportunities for Brazil to achieve its restoration goals and address water insecurity, while building climate resilience, lies in the prospect of scaling up investments in natural infrastructure. Natural infrastructure (NI) refers to strategically planned and managed network of natural lands, working landscapes, and other open spaces that conserves and enhances ecosystem values and functions. In this sense, NI can be applied throughout restoration alongside streams and provide erosion control, water purification, and flow regulation. This project is being developed in-depth 3-case studies in watersheds that provide water to the major metropolitan areas of Sao Paulo (Cantareira), Rio de Janeiro (Guandu) and Vitória (Jucu) and leveraging existing relationships with key stakeholders in the watersheds, engaging those who can contribute knowledge and information early on. Methodology is based on comparative financial portfolios and Costs/Benefits (CB) balances considering conventional-only and conventional-NI combined investments to achieve improvement in water quality and quantity. Preliminary results show investments in restoration might provide positive CB balance, depends crucially on the costs of restoration, opportunity costs of land and level of turbidity of the watershed in initial conditions. NI is an opportunity to leverage and scale up restoration once converges water supply needs and forest demand, by both mandatory, voluntary or economic initiatives.

068.05 - Ogoni Clean-Up and the Science of Ecological Restoration: The Missing Links

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In 2011, the United Nations Environment Programme (UNEP) published a ground-breaking scientific study on the impacts of oil pollution in the Ogoniland region of the Niger Delta and made a number of recommendations in which ecological restoration was a major component. This paper tries to highlight some peculiarities of the area that needs to be considered in the restoration process since the document failed to capture in perspective the critical ingredients of ecological restoration processes as

regards to reference ecosystems and the position of exotic species. The peculiarity of the Ogoniland vis-à-vis other restored environments, includes illegal bunkering and artisanal refining that takes place in the area, the lack of political will and the delay in implementation of the recommendations that followed afterwards. Beyond the deployment of some of these methods which include bioremediation, thermal desorption, bioaugmentation, pump and treat, air-sparging, in-situ chemical oxidation, peace building and ethical and attitudinal reorientation of the people will be the main driver of the restoration process for community participation and support. Nevertheless, the successful environmental restoration of Ogoniland could prove to be the world's most wide-ranging and long term oil clean-up exercise ever undertaken. Besides, the practice of ecological restoration is yet to find its roots in the country as a result of near absence of specific laws on ecological restoration. Therefore, critical revalidation and reassessment of the recommendations which will consider adequately the concerns for a proper ecological restoration that meets global standard and principles is necessary and mandatory for full recovery.

068.06 - Monitoring and modeling of hydrology, geology, and sediment and organic matter transport to support ecological restoration in semiarid ecosystems

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Information on hydrology, geology, and sediment and organic matter transport is inconsistently incorporated in ecological restoration studies, despite the fact that restoration can significantly affect and be affected by movement of water and sediment. Restoration managers who fail to consider the interplay of these dynamics when planning restoration projects may not achieve expected goals of decreased flood peaks, reduced sediment and organic matter erosion, and increased infiltration. We suggest that monitoring and modeling of physical parameters (such as groundwater levels and stream discharge), and chemical constituents (such as isotopes and carbon content) during planning, implementation, and review of restoration projects is needed to improve understanding and prediction of restoration outcomes. We present selected results of physical, chemical, and biological techniques used to evaluate restoration processes and progress at restoration sites in Arizona USA, and describe their utility in evaluating the feasibility and achievement of restoration goals mentioned above. For example, to study infiltration and groundwater processes, we used information from geologic maps (faults/lithology), water isotopes, stream gaging, water levels, and geophysical methods. To study stream discharge and sediment movement, we incorporated topography (terrestrial LiDAR/drone-based photogrammetry), soil/sediment type, and plant cover into hydraulic and rainfall-runoff models. To assess the effects of erosion control structures on sediment and organic matter storage, we combined measurements of nutrients and isotopes with information on fire and restoration history, vegetation type, and topographic setting. New insights and applications derived from these studies are being actively incorporated into restoration planning and implementation by partner organizations and agencies.

069 Restoring habitats & connectivity for wildlife

069.01 - Restoring degraded buffer forests adjacent to a protected national park to provide supplementary habitats for wildlife: experiences in rewilding from a major tiger reserve in India

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Bandipur National Park is a Protected Area and a major tiger and elephant reserve located in the Western Ghats, a global bio-diversity hotspot. Buffer forests abutting the national park provide valuable migratory paths and supplementary habitats for fauna. These buffer forests are highly degraded due to anthropogenic reasons and lack of restoration efforts, impairing their carrying capacity for wildlife. Junglescapes (www.junglescapes.org), a grassroots ecological restoration non-profit, has been working for over nine years on restoring these forests to healthy habitats with the primary goal of rewilding. Restoration methodology was focused on regeneration of native vegetation, rainwater harvesting and leveraging faunal re-habitation for faster restoration. Contour trenches on hill slopes prevented rainwater run-off and enabled grass revival, critical for attracting herbivores, and increased moisture retention for natural juvenile plants. Seeds and saplings were utilized to address keystone plant imbalances; plant species relevant to elephants were given special attention. Small water bodies were created along streams to serve wildlife and support plant species with higher water needs. Regular monitoring of vegetation and faunal presence helped assess methodology efficacy and plan course corrections. Local communities were involved actively in restoration to minimize potential anthropogenic threats. Over 1000 hectares of degraded forests were restored to healthy wildlife habitats. Progressive resurgence was recorded of multiple mammal species like elephants, Gaur (bison), deer, wild boars, wild dogs, sloth bears, etc. Strong correlation was observed between revival of ecological cycles and increased faunal presence. Tigers re-appeared after 5 years of restoration, completing the natural food chain.

069.02 - Identification of key plants for the restoration of degraded neotropical habitats based on network analysis of plant–frugivore interactions

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Ecological restoration of natural habitats is expected to take into account not only the original species composition of a given site, but also the ecological functions and interactions performed by these species. Network analyses of complex interactions have been found to provide insightful information to interpret community structure and the contributions of species in structuring these communities. Here, we investigated 17 neotropical fruit–frugivore systems, distributed over 12 distinct ecoregions, in order to identify plant species responsible for supporting a wide array of fruit-eating birds and mammals and to substantially increase the interactions between all species. Using network analyses, we compared species centrality indices and vertices universal roles as a method to detect key plant species in those 17 networks of fruit–frugivore interactions. We found that vertices universal roles were more effective in determining key plant species. Even though more basic information on fruit–frugivore interactions is needed in order to produce robust listings of key neotropical plant species, network analyses proved to be a useful tool to assist in ecological restoration plans.

069.03 - Evidences for conservation and restoration of the nesting habitat of the hawksbill marine turtle (*Eretmochelys imbricata*): Campeche, México

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The hawksbill turtle (*Eretmochelys imbricata*) is a worldwide-distributed and critically endangered species. In Mexico, it is broadly distributed along the coastal zone of the Yucatan Peninsula and Gulf of Mexico. Distinctive sandy beaches are the preferred habitat for nesting by this species. The objective of the study was to evaluate the influence of physical and environmental features of the habitat on the nesting process of hawksbill turtles, particularly on hatching and emergence success parameters, and to evaluate the importance of preserving the habitat structure or restore it. Nesting activity of hawksbill turtle was monitored along 18 km of beach in Campeche State, Gulf of Mexico. A total of 78 nests were evaluated. The biological parameters of hatching and emergence success were recorded on nests and 12 physical and environmental variables were measured on the nesting beach. Multiple regression and canonical ordination techniques were used to assess the relationships between the reproductive parameters and the habitat characteristics. Results indicated that nesting is not significantly affected by the slope and width of the beach. The depth of the nest, the distance to the highest tidemark, type of vegetation and distance to the closest vegetation, were the variables significantly associated with hatching and emergence success. Herbaceous and shrub plants were the type of vegetation positively associated to the reproductive parameters, suggesting they function as temperature regulators. Results highlight the importance to preserve the vegetation cover on hawksbill turtle nesting beaches, and reforest with particular species as essential structural component of the nesting habitat

069.04 - Improving wildlife corridor designs to mitigate the impacts of habitat fragmentation on small mammals in Peninsular Malaysia

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Habitat fragmentation poses one of the most significant threats to the structure and persistence of animal populations and communities because it inhibits movement between fragments, isolating and reducing the viability of populations. Wildlife corridors linking habitat remnants are the most widely adopted strategy for halting the effects of fragmentation. There is a lack of consensus that corridors work as intended to improve connectivity, species diversity and population persistence however. Most corridor studies have been conducted in artificially created experimental rather than natural landscapes, temperate areas, focussed on only a few species, lacked replication, or had improper controls. I addressed these gaps in knowledge by examining the community structure and movements of a large variety of small mammals in rainforests fragmented by a highway, but connected at some points by underpasses in Peninsular Malaysia. Trapping was conducted in paired grids at 18 sites, 6 each in fragmented (roadside), connected (underpass) and intact forest habitats (>500 m from any roads). Each grid had 10 Elliott and 10 cage traps with 10 m between traps. Traps were set, checked and rebaited during 6 consecutive mornings and evenings to assess the community structure and movements of both nocturnal and diurnal mammals. Species diversity was highest in forest interior habitats and lower in fragmented and connected habitats. Fragmented and connected habitats appear to have similar community structure and lack of exchange of individuals. This may be due to similar vegetation structure since both habitats are beside the highway.

S70 Second Act: The Vital Role of Tropical Forest Garden Successio

Organizer: Anabel Ford

S70.01 - Land use, Dominant Plants, and the Milpa Cycle of the Maya Forest

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It is no accident that the dominant Maya forest plants are all useful. Generations, centuries, and millennia of occupation by the ancient Maya have created a managed mosaic landscape. Today, there are tenacious Maya farmers who maintain forest gardens based on rich traditional knowledge creating the most diverse domestic system in the world. Understanding the value of the Maya farmers and the knowledge of the traditional small holders is a requisite for conservation designs for the future, one that we are applying directly at the binational El Pilar Archaeological Reserve for Maya Flora and Fauna of Belize and Guatemala. The revolutionary practice of Archaeology Under the Canopy safeguards ancient monuments from erosion-causing elements, preserves the ecology of the surrounding Maya forest garden, and reveals structures within their natural forest garden context. Heterogeneous and biodiverse, forest gardens constituted the strength of the Maya community in the past, relying on the traditional knowledge of local farming households. Today, Maya forest gardeners' intimate knowledge of their landscape is a model of a sustainable co-creative process between people and their environment that can provide inspiration for people all over our planet.

S70.02 - Archaeological shaping of the tropical forest: parks from Colombia, Ecuador and Peru.

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Today National parks are the product of the human action, we protect them, we selected and control the succession process of forest maturity, by suppressing or managing the fire, expelling humans from the woods, controlling the agent actions inside. With tourism we selected spaces of esthetic beauty based on a an iconological tradition of the beauty of nature. But what is more important, is the fact, that here is a long history of human selection. In the past humans selected the forest for wood, fruits, tools and many other uses, the mobility of hunters favored the dispersion of species to new landscapes out of the original range and transformed indirectly or directly, food producers acted on the succession cycles as well. This paper compares five National parks where I developed projects in the past years. This are the Sierra Nevada de Santa Marta and the Chiribiquete in Colombia, the Machalilla and Galapagos in Ecuador, and the Pacaya Samiria in Peru. Each one has different histories which help to approach the question, if tropical forest gardens represent an artisanal form of ecological restoration?

S70.03 - The Milpa Biome: Human management of above and below ground processes in forest garden succession

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Milpa begins as a successional polyculture centered on Zea mays and managed to ensure restoration of diverse woodlands on the field. The strategy employed imitates gap dynamics in a natural forest. The greatest impact is achieved in early succession where interventions assure the rapid establishment of fast-growing, pioneer trees that hasten canopy closure. Gradual increase in canopy growth and coverage above ground, and gradual increase in soil food web connectivity and efficiency below-ground, restore soil health for agriculture. One goal is to avoid thicket formation and shorten the length of the fallow cycle without

sacrificing long-term productivity. Maya farmers in the Lacandon jungle of Chiapas identify and favor tree species supportive of endogenous soil fertility renewal. Selection, tree-planting and use of native microorganisms as well as some controlled burning and other practices are employed. In this paper I evaluate the theoretical impact of these practices on the milpa biome and identify specific research questions we need to answer to better understand milpa agroecology.

S70.04 - Secondary forest management in Calakmul, Campeche, Mexico, an example of Maya forest garden conception.

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Secondary forests in Maya land plays an important role as source of biological diversity and ecosystem services. In Calakmul, Campeche, farmers of ejidos (communal farmland) Valentín Gómez Farías and Álvaro Obregón, practices different forest conservation and strategies management in order to halt deforestation and promote sustainable community forestry. One of them is thinning and enrichment of acahuals (secondary forest), which consist in removal of deformed trees, low-commercial-value species and dead trees, and introduction of species of particular value in stands that are in early stages of development. The introduced species fulfil different purposes, from food resource, timber and precious woods for furniture to cultural. As ecosystem services the managed secondary forest, provide reduction of greenhouse gases from the atmosphere, biodiversity conservation, climate regulation, water purification, cultural and more. In the present research the effect of forest management practices on carbon stocks (above and below ground biomass, organic matter and soil), as well as on diversity of tree species of secondary forest was evaluated. Thirty experimental plots were established in 15 year-secondary forests with different forest management (treatments): two thinning, three thinning, two thinning along with Pimienta dioica, agroforestry system with Swietenia macrophylla-Citrus sinensis and natural secondary forest (no forest management). The plots under study had no statistical differences on tree diversity richness and carbon storage compared to natural secondary forest, and additionally a gain with the introduced plant species, resulting in an increase of the use value of secondary forest.

S70.05 - Are oligarchic Amazonian forests the result of Pre-Columbian unnatural selection?

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Recent archaeological discoveries have revealed that Pre-Columbian lowland Amazônia supported extensive human settlements, sophisticated chiefdoms and skewed trophic dependency ratios. As a result, the vegetation of vast areas of the Neotropics were anthropogenic by 1492. Pre-Columbian botanical extinction, especially in places of high beta diversity such as Amazonia, must have been extensive and anonymous (that is, of species about which we will never know). The forests that remained, bio-engineered by humans, have converged on a pervasive oligarchic community structure that is predictable. The ontogeny of these oligarchies has been obfuscated by holocaust, linguicide, the facile application of environmental determinism and the abounding number of unknown species in the region.

S71 Restoring soil microbial communities

Organizer: Susanne Schmidt

S71.01 - Soil microbial restoration through reforestation in the humid tropics

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There is an emerging understanding that soil organic matter (SOM), which is integral to soil fertility and global carbon cycling, derives to a large extent from soil microbial residues. As these microbes are also the primary agents of SOM decomposition, their composition and function have influence from a local to global scale. A common approach to restoring SOM to degraded tropical soils is reforestation, but SOM outcomes are inconsistent and little is known about recovery of soil microbial communities. We assessed compositional and functional recovery of soil microbial communities under three types of reforestation just under two decades old – monoculture, mixed species and rainforest restoration plantings – on former grassland in northern Australia and the Philippines. None of the reforestation approaches recovered soil microbial composition or function to the reference levels of intact forest within two decades, with some microbial traits completely unchanged. Soil microbial composition and function were closely coupled with SOM, and correlated strongly with plant composition and function. Our results suggest that approximate restoration of aboveground structure, soil microclimate and litter input rates is not accompanied by soil microbial community restoration over the decadal time scale often focused in tropical reforestation. More rapid soil microbial restoration and, possibly as a consequence, more reliable and rapid SOM recovery, may require more targeted interventions than reestablishment of tree cover, such as soil microbial inoculations or a focus on more complete floristic recovery.

S71.02 - Fungus biodiversity, an important soil metric for successful restoration using native saplings

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Given a choice of potential areas for restoration, planting locations are often prioritised by abiotic soil parameters, such as NPK, compaction and organic matter. Surprisingly, biological soil parameters have received little attention in this respect. We evaluate if fungal biodiversity can elucidate the conditions favourable to native saplings in a region of Sao Paulo State, Brazil. We hypothesised that fungi species can be proxies for the overall ecological conditions that influence saplings because they respond differentially to myriad chemical and physical parameters, and their distribution is often influenced by relationships with other biological entities, such as pathogens. Using universal fungus primers and a metagenetic framework, we sequenced soil samples from plantations across a ~40-km region. We show that fungal biodiversity is geographically structured at both the local and regional scales: samples within a plantation tended to be more similar to other nearby samples and adjacent plantations were more similar to each other than to those geographically more distant. Importantly, non-metric multidimensional scaling (NMDS) of Beta diversity matrices was significantly correlated with sapling survival rates. Specifically, we were able to show a significant correlation between plantation success (measured as survival after the initial planting) and the first NMDS axis derived from Jaccard matrices. Our results imply that larger sample sizes will increase predictive power and we are currently populating a database with sequencing output associated to sapling mortality and other metrics from additional plantations.

S71.03 - The effect of ecological restoration on the structure of soil microbial communities in coastal wetlands

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The successful restoration of many desirable ecosystem functions, ranging from water purification to climate regulation, is dependent on soil biogeochemical processes. These processes are in turn governed largely by the complex communities of microbes that reside in the soil. The recent advent of metagenomic techniques has spurred significant advances in our understanding of the community ecology of soil microbes, but the field is still developing rapidly, and the tools and principles are just beginning to make their way into ecological restoration. In the present study, we used 16s amplicon sequencing to survey the resident microbial communities of soils sampled from wetlands with a range of land use and restoration histories. Specifically study sites were either active cranberry farms, retired cranberry farms, or former cranberry farms that had been restored to function as the peat bogs they once were. Based on previous results, these site types are known to differ in important biogeochemical functions, such as denitrification and greenhouse gas emissions, and restoration efforts do appear to put soils on a developmental trajectory toward natural reference bogs. Our project aims to characterize key differences in microbial community structure among these different site types and identify characteristics that are associated with desirable biogeochemical functions. Preliminary results will be discussed.

072 Ecological restoration & conservation in productive systems

072.01 - Are wild insect pollinators from forest habitats important to lychee fruit production in northern Thailand?

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Forest ecosystems perform fundamental life-support services, which support delivery of key ingredients of agricultural, pharmaceutical, industrial enterprises. Tropical fruit crop production may depend on pollination services provided by wild animals from restored and remnant forest habitat. However this has been insufficiently tested for tropical crops other than coffee. We tested the importance of pollination by wild insects to lychee production in northern Thailand, where small-scale orchards (0.2-1 ha) have been established, within a mixed landscape of low-intensity farmland, regrowth and old growth forests. Pollination experiments were conducted in 20 orchards, using four pollination treatments: open (unmanipulated), open with hand pollination, and both fully and partly enclosed in 10 µm mesh bags, were applied to eight inflorescences and four different trees in each orchard. Hand pollination did not produce any increase in fruit set, while pollination exclusion reduced fruit set to 35% of unbagged treatments. Insect visitors were assessed using flower observations. Hymenoptera comprised 88% of observed visits by insects to flowers. Four species of Meliponines (stingless bees) were 73% of flower visitors. Three honey bee (*Apis*) species accounted for another 12% of flower visitors. We conclude that the forest surrounding habitat in the region provided insect pollinators essential to lychee fruit production. Wild pollination service can be a key encouraging element for farmer to practice forest conservation and restoration.

072.02 - International policy of the environment and legal framework of pastureland management in the Mongolia

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The international environmental policy took a turn in the beginning of the 1990s, particularly during the United Nations Conference on Environment and Development in 1992 (The Rio Conference). The introduction of the concept of sustainable development and sustainability, which have permanently shaped this area of international law including in the field of land-uses and management, is definitely the Rio Conference's hallmark. The MEAs that have been introduced, are more or less reflecting the objective of sustainable development and the conservation and sustainable use of natural resources. In order for the MEAs to become fully operational and having the intended effects, their parties need to elaborate their principles and reflect them into the relevant policy documents and national legislation. This entails that in some cases a fundamental legal changes may be necessary. Current approaches related on pasture land in Mongolia The approach some kind of Mongolian NGO is the formation of pasture herders groups (PUGs), that will bear the main responsibilities, after the land has been divided into pasture use parcels that create favorable conditions for keeping nomadic, pastoral livestock husbandry. The right of the citizens to live in a healthy and secure environment is to be guarded and the State is responsible for mitigating particular environmental threats, such as desertification, and maintain, protect and improve the conditions of pastureland. Due to the current situation in Mongolia, there is a real need to organised pasture land uses by clearer rules on responsibilities and enhancement of the connection between the land-users and the land itself. The formation of herders' organisation and defining their rights, duties and responsibilities in law is an important factor.

072.03 - Relevance of the ecological restoration in the Estepa comarca's olive groves (Spain) based on the agricultural sustainability of mediterranean systems

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Olive groves in the Iberian Peninsula make up around 50% of the agricultural area, presenting a great socio-economic and cultural relevance, which in addition to their multifunctionality gives them priority for the application of sustainable landscape planning and management. Although the management of these systems has traditionally been extensive, since 1950s it has tended to intensify, causing undesirable degradation and increasing the soil erosion rate, which in turn provokes a considerable abandonment of agricultural land. The present study focuses on the analysis of Estepa olive region, in Andalusia, using a landscape approach through simulations of possible future scenarios. The results reveal that both integrated management and olive intensification practices are not sustainable in the long term, and that the ecological management and a proposed combined farm (integrated, intensive and ecological crops) are the most profitable options. Furthermore, the environmental impacts by-product of the agriculture must be mitigated through restoration measures, such as the use of vegetation covers to curb the erosive processes as a result of intensive tillage and the use of machinery, thus allowing a greater productivity of the system over time. Finally, the approach to strategies for restoring agrobiodiversity in abandoned agricultural areas as part of the inclusion of biodiversity and non-productive ecosystem services in the olive economy contributes to improved profitability, thus harmonizing agricultural production and conserving nature.

072.04 - Potential of uncultivated field-margins in restoring agro-ecosystems in the Mediterranean: Considering seasonal dynamics and management

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Agro-ecological practices are promoted worldwide to enhance biodiversity in degraded agricultural ecosystems. Among the most common and effective practices are conservation and restoration of natural patches and field-margins in the landscape. While mounting empirical evidence demonstrates that these practices are fruitful in temperate Europe, little is known about their effectiveness in drier Mediterranean environments. We explored the potential contribution and suitability of large natural patches and narrow field-margins for establishing an ecological corridor in Emek-Harod, an intensive agricultural area of conservation interest in the Jezreel valley, Israel. We surveyed five taxonomic groups throughout the agricultural season in common crops, field-margins, and large natural patches. Our results indicate that uncultivated field-margins are highly biodiverse for some taxa, despite suffering from high disturbances, and their relative importance varies with agricultural activity throughout the year. Opposite to our expectation, field-margins contribute more to arthropods biodiversity than the large natural patches: ground-dwelling arthropod richness was 1.5 times higher in field-margins, and parasitic Hymenoptera abundance was 1.6 times higher. Field-margins importance grows in the dry season as abundance reaches 2-2.5 times the abundance of large natural patches both for ground-dwelling arthropods and for butterflies. This pattern is not consistent with vegetation and bird biodiversity, for which richness is 1.5-2 times higher in large natural patches, and is affected mostly by management. These results indicate that field-margins are of high potential for restoration in agricultural Mediterranean regions, but we must consider focal species and their seasonal dynamics in order to better plan and implement field-margins management.

072.05 - Twenty-seven years of source-identified seed development, production, and tallgrass prairie restoration in Iowa's roadsides and agricultural lands

GREG HOUSEAL

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The state of Iowa, in the Midwest of the United States, has some of the richest agricultural soils in the world. Converted largely to row crop agriculture, less than 0.1% of tallgrass prairie remains. The Tallgrass Prairie Center, University of Northern Iowa, employs seed-based plant materials development and restoration delivery programs to recreate tallgrass prairie on the few

remaining areas of the agricultural landscape: road rights-of-way, prairie buffer strips, and on federally subsidized Conservation Reserve Programs. Research on seed-mix design and establishment are at the core. Native vegetation funding for roadsides began in 1987 with the Surface Transportation and Uniform Relocation Assistance Act (STURAA), requiring 1% of federally funded highway project's landscape budget to utilize native wildflowers. Iowa passed Integrated Roadside Vegetation Management (IRVM) legislation in 1988. A companion program, the Iowa Ecotype Project, developed and released 70 species for commercial production. Over 1.25 million pounds (567,000 kg) of source-identified seed have been produced since 1996, and 140-180 native species are certified annually. IRVM programs statewide have planted diverse prairie on 90,000 acres (36,000 hectares) since 1990. Recent work has demonstrated that planting prairie in strips on as little as 10% of row crop acres can mitigate up to 90% of sediment and nutrient run-off from agricultural practices. Currently 1.6 million acres (650,000 hectares) are enrolled in the federal Conservation Reserve Program. This presentation will showcase how these programs work in concert to create more perennial tallgrass prairie vegetation on Iowa's agriculturally intensive landscape.

072.06 - Restoring overgrazed Chaco forest: do soil chemical properties change after different years of domestic livestock exclusion?

ELIANA ARÉVALO; ANDRÉS TÁLAMO; FERNANDA MARTÍNEZ-GÁLVEZ; ANA CHÁVEZ; JOHANNA CROCE; CAROLINA TRIGO

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Extensive livestock grazing is a major conservation-management concern in many forests around the world. One way to restore overgrazed forests is with livestock exclusion. Nevertheless, we do not know experiments that evaluate the effectiveness of exclusions in the restoration of dry-forest of South America. Thus, we studied how soil chemical properties change with different years of livestock exclusion in a dry Chaco forest (NW-Argentina). We installed livestock exclusion in 2007 and 2012 following a randomized block design. Three treatments were compared: continuous year-long livestock grazing (CG), grazing excluded for 2 years (2Y), and grazing excluded for 9 years (9Y). We assessed the exclusion effects on a variety of soil chemical parameters. Results of the two-way ANOVA showed that there was no significant difference between treatments respect to pH, extractable-P, exchangeable-Na and C/N ratio ($p > 0.05$). Surprisingly, in 9Y exclusion the organic matter, organic-C, total-N and exchangeable-K values were lower than those of the other treatments ($p < 0.05$). These differences can be attributed to the lack of feces and urine from livestock in 9Y exclusion, as well as the role of livestock in other ecosystem processes such as nutrient cycles in grazed sites. If we want to maintain/increase the organic matter, C, and N values, livestock exclusion may not be a convenient restoration technique. However, because the results of the present study come from a short-term (2-9 years) experiment, we recommend a long-term research in order to a better understanding of the livestock exclusion effects.

S73 Seed-based Restoration: Innovations, Opportunities and Challenges - Getting Seeds (part 1/2)

Organizer: Kingsley Dixon

S73.01 - Can we meet the seed challenge in global restoration?

KINGSLEY DIXON

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As the speakers in this symposium will highlight, there is a growing gap between restoration need and the ability through provision of plant materials to achieve the scale of restoration hoped for and indeed, promised. Whether it is the Bonn Challenge or more modest 'backyard' restoration, seed sits at the heart of providing the foundational restorative materials. Three major issues sit at the heart of the seed-based capability to deliver effective restoration - sourcing seed at the tonnages required; ensuring seed is stored and managed to ensure effective germinative capacity and, deployment to site ensures seed wastage is minimised. These three core areas are the backbone of moving forward with seed-based restoration. The International Network for Seed-based Restoration (INSR), the only seed-dedicated restoration organisation and a Section of the Society for Ecological Restoration (SER) International is committed to linking seed producers and seed users for more effective global outcomes. From China to Surinam to sub-antarctic islands, restoration is now an effective partner in delivering conservation with effective seed use being critical to ensuring on-going growth and success in delivering a greener more biodiverse world.

S73.02 - Prioritizing seed needs and seed transfer in the Western United States, a cooperative effort

FRANCIS KILKENNY; FRED EDWARDS; SARAH KULPA; JOHN PROCTOR

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The United States Forest Service, Fish and Wildlife Service and Bureau of Land Management are cooperating on developing seed transfer guidelines and plant materials for priority grass and forb species for use in restoration in the Great Basin and arid ecosystems across the Western United States. This talk will discuss the prioritization process, including how expected disturbances influence where needs will occur, how knowledge on ecological processes is being leveraged, and what taxonomic and genetic considerations are being addressed. Aspects of the prioritization process are being developed into a seed menu tool that will be made available to managers in the region. This talk will also discuss coordination of seed collections across a large region, using agency support in cooperation with the Chicago Botanic Garden's Conservation and Land Management Internship Program, and the development of a common garden network, with agency and University cooperators, to test seed transfer distances for priority species.

S73.03 - Selecting species and seeds for forest restoration in tropical rural landscapes

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Restoration projects of highly diverse forest should integrate relevant ecological, social and technical criteria to select species for reintroduction. In Marqués de Comillas municipality, southeast Mexico, we used five criteria relating ecological, social and technical information to select tree species for riparian forest restoration. We targeted on species that (1) are important in the reference forest; (2) are less likely to establish following disturbance; (3) are not specific to a particular habitat; (4) are socially accepted; and (5) their propagation requires a reasonable time and financial investment. Out of a local pool of 97 species, we identified 30 target species that together represented >60% of the species importance value in the reference forests. For 20

species reintroduction by means of active restoration was deemed necessary. Nearly half of the species showed technical constraints for easy propagation and seeding. The selection processes involved participation of local communities, in order to promote their involvement and empowering. Species that established through natural regeneration, following secondary regrowth, had lower social value among local farmers. The progress of the project gave encouragement to young people of one community. They applied for and got financial support to build a nursery and received training on seed collection and propagation from governmental agencies. The nursery produced thousands of native plants, and was included in the list of nurseries supplying plants for restoration projects funded by public agencies. Seed collection and management, and plant propagation may be good options for social involvement in restoration projects.

S73.04 - Seed sourcing: How to make the best decisions about what seed provenances to collect and where to use them in restoration

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Proper sourcing of seed for ecological restoration has never been straightforward, and it is becoming even more challenging and complex as the climate changes. For decades, restoration practitioners have subscribed to the “local is best” tenet, even if the definition of “local” was often widely divergent between projects. However, given rapid climate change, we can no longer assume that locally-sourced seeds are always the best option. We discuss how plants are responding to changing climates through plasticity, adaptation, and migration and how this may influence seed sourcing decisions. We review provisional seed zone maps and seed decision tools, including a new tool under development to assess options of plant provenance based on the goals and context of a given project (based on results from a workshop hosted by Mt. Cuba Center in Delaware, USA). We recommend focusing on developing adequate supplies of “workhorse” species, undertaking more focused collections in both “bad” years and “bad” sites to maximize the potential to be able to adapt to extreme conditions as well as overall genetic diversity, and increasing seed storage capacity to ensure we have seed available as we continue to conduct research to determine how best to deploy it in a changing climate.

S73.05 - Collecting Wildland Seed: Selecting Seed Sources and Insuring Genetic Diversity

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A vital element of any restoration project is the selection of ecologically appropriate species based on inspection of planting site conditions and reference areas. Planting site-adapted, genetically diverse seed is essential to provide resiliency to climate change and other disturbances. Provisional seed zone maps based on climatic and other environmental factors may be used to select areas for harvesting seeds. In the western United States, species-specific seed zones developed from genecological studies are available for a limited, but increasing number of widespread restoration species. Seed zone maps and related tools are available online. Additional factors, including requirements for sub-specific taxa or ploidy levels or restriction of collection to specific elevation bands may further direct harvesting. Seed collection protocols recommend harvesting from at least 50 widely separated plants in each of five or more populations within a seed zone to insure genetic diversity; additional guidance is provided to insure collection of mature seed and preclude excessive harvesting. As an alternative to in-house and contract collection and commercial purchases, non-profit seed cooperatives offer a means of stabilizing seed supplies of local sources in areas with land ownership mosaics. Cooperatives collect species agreed upon by the members, arrange for storage, coordinate grower contracts, and handle sales to members. The Deschutes Basin Native Plant Seedbank in Central Oregon, USA, for example, sells approximately 3,000 pounds of native seed annually to federal, state, and local governments, NGO's, utility companies, and private landowners.

S73.06 - From the flower to the field: Global examples of best-practices for collecting seeds from the wild for use in restoration

STEPHANIE FRISCHIE; KINGSLEY DIXON; CÁNDIDO GÁLVEZ RAMIREZ; STACY JACOBSEN; MARIA TUDELA ISANTA; GREG LIVOVICH
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Multiple options are available for obtaining seeds to use in restoration and the method of choice will vary depending on project goals and constraints. Seeds collected from natural and spontaneous plant populations are important as restoration seed mixes, foundation seed for establishing production beds, germplasm for developing cultivars, and seed bank accessions for research and ex situ conservation. For most regions and for most species, seed farming is nonexistent, impractical, or insufficient to meet the demand of seeds for restoration. We discuss the range of approaches for obtaining seeds: wild collection, contract collection, in-house production, purchase and the advantages/disadvantages of each. With experiences and practices from around the world, we give practical considerations for making wild collections: planning which species and quantities, locating populations, securing permission, evaluating populations, collecting the seeds, recommendations for tools and field safety. Particular examples come from South America (Bolivia), North America (USA: California, Indiana, Illinois, Montana), and Europe (Spain, Italy and Scotland). Finally, we review best-practices for seed handling and short-term storage of seeds between collection and deployment.

074 Plant species and populations as restoration targets

074.01 - Restoration potential of *Quercus humboldtii* forests in natural reserves of the eastern range Colombian Andes

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Quercus humboldtii, an endemic species of Colombia and Panama, predominates in remnant forests (known as “oak forests”), important because they create a microclimate, serve as a refuge and feed groups of amphibians, reptiles, birds and mammals. *Q. humboldtii* is threatened by deforestation, illegal logging, charcoal production, extraction of bark for tanning and extension of the agricultural frontier. The natural reserves of Zapatoca civil society (Santander, Colombia), including ‘El Páramo-La Floresta’ and ‘La Montaña Mágica-El Poleo’, eliminated the tensors of more than 30 years of agriculture, livestock and deforestation. This study evaluated the state of at least five years of passive restoration and established a base structure and vegetation dynamics to propose restoration interventions. The biomass of the remaining trees and regeneration in more conserved areas increased in two years. However, the mortality rate was 50% for regeneration in the most disturbed areas, where ruderal species dominate, outcompeting and displacing native species. In order to facilitate the establishment of local species, to accelerate the rehabilitation process and to create microsites, nuclei were established with stakes (> 2 m long, 5 cm in diameter) of *Trichanthera gigantea*, *Escallonia pendula* and *Ficus crocata*. After six months, the survival of ca. 60% suggested potential for adaptation to stress and facilitation for other species of ecological importance. In this way we hope to enrich the nuclei with native species and to achieve the future recovery of the oak forests.

074.02 - Spatial structure of *Litsea glaucescens*: Information to restore its populations in Oaxaca, Mexico

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Temperate pine-oak forests in the Sierra Norte de Oaxaca, Mexico, have been logged for more than six decades. During this period harvesting has been directed to important timber species, relegating those with less economical value. To determine the effect of logging on the population structure and spatial patterns of *Litsea glaucescens*, a subcanopy species with culinary, spiritual and cultural importance, we designed a study in four forest management conditions in the study area. Sixteen permanent sampling plots of 625 m² (25 x 25 m) were established. The structure was characterized by the importance value index (IVI) and the diameter distribution. The spatial distribution and correlation patterns were determined for development stages of *L. glaucescens* through $K(t)$ and $K12(t)$ Ripley’s functions, respectively. According to the IVI the species with higher structural importance were *Pinus patula*, *Quercus laurina* and *L. glaucescens*. The diameter at breast height of *L. glaucescens* individuals ranged from 5-68 cm. The spatial distribution pattern was clumped and random for the developmental stages of this species, while the spatial correlation was spatially independent. The density of juveniles of *L. glaucescens* was higher in harvested areas, despite during harvesting operations all individuals are removed. Under closed canopy conditions the regeneration of this species is mainly by seed, where the density of juveniles was similar to that found in harvested areas.

074.03 - Ecological niche of an endangered pioneer species, what can we learn to restore its population? Experiments with the dwarf bulrush (*Typha minima* Hoppe)

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The dwarf bulrush (*Typha minima*) is a pioneer, light demanding species colonizing riparian flood plains of temperate mountain streams. Its number declined by more 80% over the European Alps and its larger remaining populations are located in French alpine rivers. *T. minima* populations are regularly impacted by river management, including flood control works. As a protected species, impacts on its populations have to be compensated by different methods. In order to find the most relevant one, our first objective was to define its ecological niche. Medium-scale hydrogeomorphological parameters, as well as small-scale abiotic and biotic parameters were measured inside and outside its presence areas. Surprisingly, we found only one small-scale abiotic parameters to significantly have an effect on *T. minima* presence: elevation from the mean water level. Our second objective was to determine the best methods to restore viable populations. Some clones were collected in wild populations and grew in nursery. They were then transplanted with three methods: bare roots, small containers (9cm diameter) and large containers (33cm diameter). We monitored these experiments implemented along a river between 2013 and 2016 by measuring shoot frequency, rhizome growth and patch expansion. Our results show that the more biomass is provided during the transplantation, the more rapid is the colonization. More research is therefore needed 1-on its niche to understand the spatial dynamics of its population and why hydrogeomorphological parameters had no effect on *T. minima* distribution and 2-on the restoration method, to reduce the costs and ensure lasting viable populations.

074.04 - The effect of prescribed burning, initial watering and grazing on the restoration of Mediterranean *Brachypodium retusum* populations

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Brachypodium retusum is the dominant species of Mediterranean steppes in Spain and Southern France. However, once the species disappeared by human interventions involving soil disturbance spontaneous reestablishment is very low even if source populations are close. Plant community restoration remains incomplete if the dominant species of the reference system is lacking. In the present study, we are testing the major environmental factors that may influence reestablishment. We hypothesize that controlled fire and grazing reduce competition and favor *B. retusum* due to its high resprouting capacity. It has also been reported that wildfires increase seed production of adult populations while seed production is very low without fire. We further hypothesize that initial watering increases seedling recruitment although long-term watering favors competitive ruderal species. The experiments were started in 2016 using the northernmost Mediterranean steppe of "La Crau" (South-Eastern France) as a model system. Due to its unique floristic composition providing a habitat for several rare bird species the area is protected as a nature reserve. In particular, intensive agriculture has destroyed a large part of the steppe area. Experiments were run on a former arable field and in the pristine steppe. First year results showed a negative effect of burning and grazing on cover and inflorescence production of *B. retusum*. In the beginning, recovery was not higher than in surrounding species. However, no negative grazing effect on *B. retusum* was observed in burned plots. The 2017 results will be presented at the SER conference (data not yet available).

074.05 - Effect of coverage and soil water storage capacity on performance and growth of *Nothofagus alessandrii* plants on water deficit conditions

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Nothofagus alessandrii is a threatened and endemic species from the Mediterranean forests of Chile and although its restoration is a priority, there is scarce information regarding silvicultural techniques for its establishment. On semi-controlled conditions, an experiment was established, evaluating the effect of three coverage levels (no coverage, mesh with 35% and 80% of coverage) and two substrate types (mineral soil with and without peat on seedlings in pots. After 1 month since establishment with watering at 80% of soil water storage capacity (WSC), a sample of seedlings were faced to water deficit (WD) during three months (without watering). After the WD period seedlings were rehydrated with watering at 85% WSC for one month. Other sample of seedlings kept the watering protocol at 80% WSC during the entire experiment. Our results indicate that under WD higher coverage generate conditions that favor seedling performance, such as increasing daily minimum relative humidity, and lowering daily maximum temperature. Fv/Fm values of 0.56 ± 0.05 , 0.63 ± 0.04 and 0.70 ± 0.02 for treatments without coverage, 35% and 80% coverage, respectively, were observed. Seedlings that not faced WD presented Fv/Fm values of 0.72 ± 0.01 . Mineral soil with peat increases WSC in 7.5%, but an increase in soil moisture loss rate was observed. Also, at higher coverage and soil water content, stem length increases (66.8 ± 3.0 cm for 80% coverage and 21.1 ± 1.3 cm without coverage, in watering conditions). In this context, it is possible to indicate that an increase in coverage on *N. alessandrii* plants during a period of WD, generate conditions that favor morpho-physiological performance.

074.06 - Insights into landscape genetic structure of three short range rock outcrop endemic plant species using resistance surfaces

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Rock outcrop habitats including banded iron formations (BIF) are found globally and are often hotspots for endemic species diversity because of their unique edaphic challenges when compared to the surrounding landscape matrix. They are frequently topographically complex and disjunct in nature and the importance of dispersal in maintaining connectivity in patchy habitats is poorly understood. Landscape features can either facilitate or act as barriers to dispersal and information on how they affect gene flow is critical to our understanding of how populations diverge and ultimately speciate. Here we examine the effect of landscape features on genetic connectivity of three narrow range plant species endemic to BIF and surrounding slopes potentially impacted by mining activity, in south-western Australia. We analysed spatial genetic patterns at nuclear microsatellite loci and developed resistance surfaces that were hypothesised to influence dispersal success and ask, which landscape features best explain connectivity. All species had a significant ($p < 0.01$) positive association with geographic distance (IBD), habitat (CH), topographic complexity (CTC) and plant density (CD), irrespective of genetic differentiation metric used as the response variable. Multiple matrix regression showed that all variables exhibited unacceptably high levels of multicollinearity to develop models with more than one variable and so the most parsimonious models were found from backward selection. This resulted in the choice of IBD as the most explanatory variable for *Acacia adinophylla* and CH for both *Lepidosperma bungalbin* and *Tetratheca aphylla* subsp. *aphylla*. We discuss the implications of these findings for the conservation and restoration of rock outcrop species.

S75 Institutional arrangements fostered by the Brazilian Forest Service (SFB) to support initiatives for restoration of rural degraded areas in Brazil. - Subsection 2

Organizer: Janaina de Almeida Rocha

S75.01 - From environmental liabilities to forest restoration

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Due to the significant devastation suffered by the Atlantic Forest, the Prosecution Office of the State of Bahia decided to investigate the environmental situation of the areas with eucalyptus plantation. In 2008, an inspection action was taken on the participants in the Forest Producer Program, with 571 properties visited and 461 tax assessment notices drawn up.

The investigation concluded that pulp producers were responsible for promoting economic activity in environmentally protected areas. Through an out-of-court agreement, obligations were established to repair the environmental damages found and to pay compensation for several years of wood consumption in environmentally irregular areas, with a contribution of R\$30,000,000.00 over 10 years.

The first obligation consists of environmental suitability of its own rural properties and assistance to the fostered areas, currently covering more than 1.000 properties, with an area of almost 400,000 hectares. This is one of the largest environmental adequacy projects for rural properties in Brazil.

With regard to compensation, the Arboretum Program for the Conservation and Restoration of Forest Diversity was implemented, which provides broad support for forest restoration in the region. The Management Council is composed of actors involved in research, extension and standardization. Its lines of action encompass a network of seeds and seedlings, planting and monitoring, environmental adjustment of rural properties, environmental education and production of technical and scientific knowledge. Its physical structure relies on the Restoration and Conservation Base for Forest Diversity and seed collection, seedling production and planting centers.

S75.02 - The Arboretum Program : A model for balancing social, economic and biodiversity objectives.

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The Arboretum Program is an example of a strategic arrangement for conservation, restoration and enhancement of forest diversity in the central region of the Atlantic rainforest in eastern coastal Brazil, a region with well known forest potential and one of the highest tree species diversity on the planet.

The Arboretum is an inter-institutional program that strategically concentrates different expertise related to research, policy, and extension, designed based on recognition of the unsustainable use of the region's natural resources, the need to improve the restoration methodologies of Atlantic rainforest cover, and an understanding of the region's enormous social and forest diversity potential.

The Program has a local Conservation and Restoration Base that provides technical and logistical support to many rural community groups for seed collection, seedling production and seedling planting. The community groups, includes indigenous people, settlers, and traditional communities. The Base is one of Brazil's leading seed warehouses, providing storage, analysis, and acquisition of seeds, facilitating community sales of seeds, and offering a place to conduct research on seed technologies for many tree species.

The Arboretum is providing a national example of how to organize action throughout the forest chain. It responds to the demand for forest resources and catalyzes income generation by traditional and rural communities as well as the generation and dissemination of traditional knowledge about these resources.

The Arboretum is delivering results from the restoration, considering the balance between social, economy and biodiversity, is a model for possible replication across the world.

S75.03 - ‘Right’ species in the ‘right’ places: What should we know about the species we use in restoration plantings?

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Forest restoration projects are aimed at restoring not only fast growing pioneer species but also the species of trees of more advanced successional stages. These late successional species represent the bulk local floras, including endemic and rare tree species. Widespread pioneer species are commonly used to restore ecosystem properties relatively quickly, since most pioneer species grow fast and aid in recovering soil properties, thus resulting in accelerating succession in formerly degraded sites. Because of the ambitious goals of restoring millions of hectares worldwide in the near future, most forest restoration projects have focused much more on structural and functional than floristic recovery. Here I discuss the process of species selection for restoration projects and highlight the risks associated with inappropriate species selection, especially for biodiversity conservation. Examples of pioneer species used in restoration projects that have become invasive are used to illustrate the effects of inappropriate species choice. Examples of poor understanding of local floras are used to illustrate the low effectiveness of restoration projects to recover late successional species populations. Using a spatially comprehensive database of forest inventories from southern Bahia, a region known for its high levels of plant species diversity and endemism, I present an approach of species selection for restoration projects that includes species range, incidence and abundance. The ultimate goal of this approach is to promote floristic recovery rather than just structural and functional recovery in restored lands.

S75.05 - How to integrate public and private forestry investment in Brazil

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Brazil has a policy of forest public lands with the designation of legally protected areas for nature conservation and sustainable production. Since 2012, with the Brazilian forest code, and with the implementation of the main management tool for the remnants of native vegetation in private rural areas - the Rural Environmental Registry (CAR) - it has been identified that the native vegetation area in private rural properties is compatible with the area in conservation units. This strengthens the planning for forestry business, integrating public and private investment strategies. Reforest with native species is currently the most cost-effective way to mitigate climate change, increase water availability, and improve current production models.

For forest development in Brazil, this is the ideal time for the reforestation of native species to gain scale and compose investment portfolios. Attract public and private capital will be key to meeting one of NDC's Brazilian targets for the Paris Accord - to reforest 12 million hectares by 2030. The concatenation of data from national forest inventories, forest research institutions, forestry industries, mapping The CAR and the environmental regularization programs of rural properties in Brazil demonstrate opportunities for investment in native species. By linking fiscal incentive strategies, stimulating research, development, and social engagement, this section will demonstrate innovative models for implementing national public policy and resources and international donations as catalysts to establish the appropriate scenario for large-scale forest investments for native species in the Brazil, with commercial purpose, and of water production and climate quality improvement.

S77 Importance of the spatial analyst in the restoration ecology. a primary tool to design, planning and monitoring

Organizer: Paola Isaacs Cubides

S77.01 - From global targets to local realities through spatial data analysis of forest landscape restoration opportunities

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The Bonn Challenge seeks to identify and begin implementation of forest landscape restoration on 150 million hectares of degraded and deforested land by 2020 and 350 million hectares by 2030. The international commitment to forest landscape restoration is strong, however the practicality of implementing these commitments at national or sub-national scales requires a translation of global ambition to local action. Spatial data analysis in forest landscape restoration assessments often answers some of the most pressing questions in restoration: where to restore and why restore in a specific area? This session will focus on several of the methods and tools that restoration practitioners have used throughout the IUCN Secretariat, member organizations, and partners. Using spatial data analysis, restoration practitioners have assessed the landscape context of restoration for a diverse set of aims using a broad suite of spatial data to map functional degradation, restoration opportunity, and the provision of ecosystem services.

S77.02 - Using landscape analysis as a participatory tool in Ecological Restoration activities: The Case of SIGWEB system of Atlantic Forest Restoration Pact

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The Atlantic Forest Restoration Pact (AFRP) is a multisectoral coalition whose goal is to restore 15 million hectares by 2050. To achieve this goal, a SIGWEB system was developed to follow and monitor restoration projects throughout the area of the Brazilian Atlantic Forest. This system is directed to the practitioners who develop their projects in the field and has an interface directed to the use of these actors. The purpose of this presentation is to present the SIGWEB system of the AFRP and its positive impacts to scaling up and open socioeconomic opportunities within the restoration value chain.

S77.03 - The importance of the restoration for the provision of ecosystem services in the regional landscape, with emphasis on the diversity of plants

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Tropical forests provide a variety of ecosystem services at the local to global scale. Besides several studies have shown that deforestation result in the loss of ecosystem functions and that our present knowledge about the key processes and functions that support these ecosystem services is limited. In already deforested areas, forest restoration is expected to increase ecosystem services in agricultural landscapes. However, there is little scientific information about whether or not forest restoration results in the recovery of key ecosystem processes and functions. Forest restoration in the Atlantic Forest in Brazil, one of the world's hotspots for biodiversity, can result in the recovery of a certain level of services from a total that have been lost and what are the institutional arrangements that allow forest restoration to occur. We argue that recovery of ecosystem services can only occur if: 1) certain critical underlying ecological processes and ecosystem structures ("biophysical conditions") are recovered; 2) the institutional arrangement (landholders attributes and rules in use) favors recovery; 3) critical social processes guarantee an equitable distribution of costs and benefits among different stakeholders. The overarching rationale is the need for science

based information about the capacity of restored forests in Brazil to provide specific ecosystem services deemed necessary to society in light of population growth and agriculture expansion. This is necessary not only to help biodiversity and assist in the recovery of ecosystem services but also to help policy makers create incentives and strategies that will help the implementation of more forest restoration projects

S77.04 - Spatially-explicit Optimization of Economic Incentives for Landscape Restoration

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The Climate Change represents a major threat to the economic and human development especially in emerging economies around the world. Poverty and inequality have the potential to increase as a result of extreme events such as hurricanes or severe droughts. In Latin America and the Caribbean Region (LAC), a significant amount of greenhouse gas (GHG) emissions are produced from land-use changes from forest to agriculture. Landscape restoration can lead to an increase in rural development by sustainably improving agricultural productivity, habitat quality for wildlife species, water security, soil conditions and other services on degraded lands. A key question that many experts in the area have posed is how much landscape restoration cost? Moreover what is the role of the public sector in promoting restoration activities? Many of the benefits of the restoration process can be cataloged as non-market type (e.g. environmental services, carbon, etc.), although there are benefits such as timber, biomass and/or the revenues from improving agriculture productivity. In this study, we developed a spatially-explicit resource allocation model to prioritize the use public incentives for forest and landscape restoration, optimizing different social, environmental and economic objectives. We developed our research in Guatemala where National Forest Law PROBOSQUE incentivizes restoration activities. Results from the model will be helping government officials and landowners to better plan deployment of resources according to different objectives. The potential benefits of this model include to balance cost of restoration, maximize the benefits with limited resources and prioritize regions in a strategic plan.

S77.05 - Prioritising sites for restoration through spatially explicit criteria and indicators at the landscape scale

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Landscape transformation by human pressures has led to a crisis of biodiversity conservation and consequently a loss of ecosystem service. Strategies of landscape restoration based not only on recovery biodiversity but ecosystem services have taken importance in the last years. Ecological criteria of systematic planning along with spatially explicit modeling techniques can contribute to the prioritization of sites for restoration. The objective of this study was to perform a spatial multi-criteria analysis in GIS for a systematic identification of priority sites of ecological restoration. Expert consultation and literature review were conducted for the selection of prioritization criteria as well as a participatory GIS approach for validation of priority sites. The following criteria (and indicators) were selected and mapped for the entire landscape: (i) vulnerability (ecosystems affected in the last three decades by fragmentation, degradation, human disturbance or deforestation); (ii) decline in representativeness (loss of weekly represented ecosystems in protected areas, and decline in population of threatened species); and (iii) decline in irreplaceability (loss of areas delivering unique ecosystem services, loss of habitat for specialist species and loss of riparian vegetation). Each of these indicators were standardized, mapped and weighted using an analytic hierarchy process. Results revealed that most of the priority sites for restoration corresponded to areas for recovering regulating ecosystem services such as head watersheds and riparian vegetation. A map of priority sites for restoration was delivered to decision-makers as input for the design of an ecological infrastructure.

S77.06 - Prioritizing restoration areas in Colombia, multiscale and multiecosystem approach.

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Colombia is committed to restoring one million hectares by 2020 as part of its signature in the AICHI and Bonn Challenge goals. The Humboldt Institute has been working on the development of protocols to effectively address restoration from planning, design, implementation and monitoring to different scales and in different ecosystems, to determine the most appropriate limitations and techniques for assessing and prioritizing areas of concern based on the use of spatial analyst tools and geotechnologies. At the nation level, a multicriteria evaluation was carried out, including areas with conflict of use, deforestation, degradation of natural coverages and loss of vegetation in drainage. This prioritizing about 190,000 ha in critical condition and about 22 million in degradation. Windows have been worked on priority ecosystems such as the dry forest, the most threatened forest in the country, where more than 90% of its coverage has been lost and the efforts are aimed at rehabilitation and reclamation. For the páramo ecosystem, they present their majority in conservation, but that must address tensionantes like mining, cultures and “potrerización”. In the case of wetlands, a different approach must be taken given their dependence and water-related regimes, where their high pollution and transformation status is first prioritized, must difficult to mapping. Finally, areas of Andean forests have been prioritized because of their high biodiversity, but where restoration reduces pressure on forests, including productive reconversion with sustainable use. We still need to deepen priorities in savannas, whose vegetation structure makes it difficult to include them with geotechnologies

S78 Restoration Economy I

Organizers: Rubens Benini & Aurélio Padovezi

S78.01 - Costs of ecological restoration in Brazil

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Aiming to subsidize actions and policies for the development of large-scale restoration in Brazil, the Institute for Applied Economic Research and The Nature Conservancy, started an important study to estimate the costs of implementing key ecological restoration techniques in regions of Brazil. The project also has the support of the Brazilian Agricultural Research Corporation (EMBRAPA), the Brazilian Ministry of the Environment (MMA) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). Initially we identified widely used techniques by consulting executives from restoration projects, further characterizing each in terms of required management activities, steps and inputs. Recognizing that initial site conditions play a role in restoration costs, we define two hypothetical scenarios presuming two levels of intervention necessity: Favorable Environmental Conditions – FEC and Unfavorable Environmental Conditions - UEC. Next, we estimated costs for acquisition of each input and execution of each management activity based on data collected from establishments in the restoration sector. The estimated average cost of restoration (US\$/hectare) for evaluated techniques considering both FEC and UEC scenarios is, respectively: dense tree planting of several species through seedling: US\$ 2,271 and US\$ 6,081; dense tree planting of several species through seed: US\$ 2,966 and US\$6,727; density-improvement tree planting through seedling/enrichment planting through seedling: US\$960 and US\$3,323; density-improvement tree planting through seeds/enrichment planting through seeds: US\$172 and US\$2,033; management of advanced natural regeneration: US\$301 and US\$707. The great difficulty of collecting information (e.g. Pantanal and Pampa biomes) highlights the necessity for discussions about ways to monitor restoration costs in Brazil.

S78.02 - How large-scale reforestation with native species can help countries achieve their NDC targets and establish a new forest economy: Preliminary findings of the VERENA project in Brazil

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Boosting the reforestation of native species at scale is an alternative that can generate multiple economic, social, and environmental benefits for Brazil and constitutes an important contribution to Brazil's NDC and the global restoration goal to restore 350 million hectares of degraded lands and forests by 2030.

The VERENA (Economic Valuation of Reforestation of Native Tree Species) project is focused on demonstrating the economic viability of large-scale reforestation with native trees by identifying and disseminating comprehensive information on existing investment cases in Brazil. In order to achieve this goal, 10 investment cases were selected to support the development of a robust economic model and build at least five business cases to be presented to a wide range of stakeholders, including institutional investors, landowners, financing institutions, and governmental agencies. The economic modelling is focused on operational procedures (planting and management); cost of capital; and the economic and financial results (NPV; IRR; Payback; profitability ratios; solvency ratios; cash flows from operating, investing and financing). Additionally, we assess the natural and human capital, with inputs from different streams of cash flows (such as: carbon stock; water flows; preservation area leases; and others). It is ultimately important to calibrate the model on robust business cases with credible and transparent information. Finally, R&D for native tree species to increase yields and improve best management practices is urgent, as productivity is a major driver in our economic valuation.

S78.03 - Commercial Pathways to Forest Carbon Sequestration

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Carbon sequestration in forest landscapes is among the largest opportunities for changes in land use to contribute to climate change mitigation. Realising such opportunities will require an unprecedented global transformation of land management across hundreds of millions of hectares of forest and former forest land. An increasingly important question is the role that the commercial forestry sector can play in this transformation. Forest sector modelling reveals large opportunities for the private sector to support forest carbon sequestration on both the supply and demand side. On the supply side, improved models of plantation forestry and management of semi-natural production forests can enhance carbon sequestration in forests and wood products, while also improving profitability. On the demand side, measures to expand sustainable wood demand, improve the efficiency of wood value chains and increase wood use in long-lived applications can deliver large amounts of mitigation through increasing the wood product carbon pool, substituting for carbon-intensive materials and driving creation of new well-managed plantation forests on degraded land. However, the mitigation potential of commercial forestry is also fundamentally constrained by future wood demand. To meet global goals for forest sector mitigation, and to sustain forest ecosystem services and biodiversity, a spectrum of complementary commercial and non-commercial strategies will be needed spanning wood production, agroforestry and large-scale restoration of natural forest.

S78.04 - The importance of an R&D platform to the success of a new forest economy and Brazil's NDC target based on silviculture with native species

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To stay within the 1.5°C trajectory and minimize the impacts from climate change, the world needs to significantly increase efforts to reduce emissions and increase carbon sequestration from the atmosphere. Large-scale forest restoration and reforestation is currently the most cost-effective way to do this. The reduction of cost and increase of products and services provided by forest restoration and reforestation is a must to attract private and public investors (institutional, farmers, private companies, etc.) to support the implementation of Brazil's NDC target to restore and reforest 12 million hectares of forests. Therefore, to achieve this ambitious target it is necessary and urgent to invest on the establishment of a robust and long-term R&D program. The Brazilian Coalition on Climate, Forest, and Agriculture decided to lead the development and establishment of a pre-competitive R&D platform for silviculture of Brazilian native species, focused on a limited number of species based on their economic value, domestication level, adaptation to climate change, potential to sequester carbon, and ecological relevance. The platform will use the best forest technology and innovation available for seeds and seedlings production, pest and disease control, management, and genetic improvement. The platform has an ongoing technical and scientific committee outlining the research priorities and monitor the results. In the short term the platform will de-risk future cash flows of benefits by producing evidence on the potential to increase yields of the main native species and develop low-costs technologies to reduce the cost of the restoration and reforestation.

S78.05 - Estimating the Size and Economic Impact of the US Ecological Restoration Industry

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Suggestions that environmental regulations that require ecological restoration are job killers have been made in the absence of broad-scale empirical research on the economic output and employment resulting from environmental restoration, restoration-related conservation, and mitigation actions – the activities that encompass the “restoration economy.” We conducted a national survey of businesses that participate in restoration work in order to estimate the total sales and number of jobs directly associated with the restoration economy, and to provide a profile of this nascent sector in terms of type of restoration work, industrial classification, workforce needs, and growth potential. We used survey results to construct a national input-output model (IMPLAN 3.1), estimating the direct, indirect, and induced economic impacts of restoration activities. We find evidence that the restoration industry not only protects public environmental goods, but also contributes to national economic growth

and employment, supporting as many as 33 jobs per \$1 million invested, supporting 1.48 – 3.8 additional jobs for each restoration job, and increasing economic output by 1.6-2.59 per \$1 invested in restoration. The literature also shows that restoration investments have strong localized economic and employment impacts based on the tendency for projects to employ local labor and materials. Our survey and modeling work reveal that the domestic ecological restoration sector directly employs ~ 126,000 workers and generates ~ \$9.5 billion in economic output (sales) annually. This activity supports an additional 95,000 jobs and \$15 billion in economic output through indirect (business-to-business) linkages and increased household spending.

S78.06 - Developing Costs for the Implementation of Ecological Restoration Projects: Construction, Planting, and Maintenance

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Costs for the construction of ecological restoration projects are often higher than anticipated by agencies and institutions who have likely spent years on land acquisition, project design and permitting, but have not considered all the short and long term construction project costs. We find that contracts that require guaranteed project performance, such as specific hydrologic conditions and/or vegetation cover, will lead to much higher construction costs as the contractors will need to build in additional contingency fees. We provide examples of how to develop a budget for construction and planting. We also provide examples for estimating pre-construction costs (e.g. invasive species control work); soft costs (e.g. agency meetings); and post construction work such as monitoring and reporting. It is our opinion that costs for the construction of ecological restoration projects may be reduced if the Ecological Restoration Practitioner and the lead Agency assume responsibility along with the selected contractor to ensure project success.

S79 Making the most of birds and mammals in restoration

Organizer: Wesley Silva

S79.01 - What we know and don't know about the role of birds in forest restoration

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Field research has increased understanding of the ecological functions of birds in tropical forest restoration sites, as well as the local and landscape-scale factors that influence bird use of such sites. Significant gaps remain, however, in knowledge about: 1) the range of ecological functions in which birds may be involved, 2) how to attract specialist birds, e.g. large-gaped species that disperse large seeds and 3) the degree to which research in other managed ecosystems can be applied to restoration systems. Although we know that birds are important seed-dispersers in tropical forest restoration sites, we know less about their roles as pollinators, dispersers of fungi, and consumers of herbivorous insects, interactions through which birds may affect plant establishment and reproduction. We know that greater structural complexity, of both individual plants and entire restored areas, attracts generalist birds; these effects can interact with landscape-scale tree cover to influence generalist bird activity levels. Few studies have investigated site characteristics that might attract specialist birds or the likelihood of being able to mimic the activities of specialist birds through other means, for example by increasing the availability of large-seeded plant species. Finally, given limited research resources, determining which findings on birds in other managed systems (e.g. agro-ecosystems) are likely to apply to restoration systems will increase our capacity for providing useful information to restoration practitioners.

S79.02 - Multiple roles of birds and mammals as drivers of rainforest restoration trajectories

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Practical actions for rainforest restoration typically involve plants alone; animal communities are often neglected during design and monitoring of restoration projects because it is assumed that: (1) they are passengers in ecological restoration, and their recovery will automatically follow if vegetation is floristically reconstructed; and (2) trajectories of change in restored vegetation are largely driven by physical factors such as soil and climate, rather than by interactions with animals. However, the reproduction and regeneration of most woody-stemmed rainforest plants are governed by trophic or mutualistic interactions with birds and mammals – plant dispersal and colonisation are often dependent on frugivore-mediated seed transport, and survival of seeds and seedlings is limited by feeding activities of granivores and herbivores, whose abundance and composition are in turn influenced by the occurrence of carnivores, leading to complex cascading relationships within multispecies food chains. I will illustrate these processes using examples from research into interactions between plants and animals during both active and passive restoration of Australian rainforests. Research results show how a site's bird and mammal community is crucial to the longer-term developmental trajectory of its floristic diversity and composition, and that the functional and species composition of birds and mammals can either accelerate recovery (leading to the re-establishment of diverse rainforest on formerly cleared land), or promote degradation (reduced regeneration and declines of rainforest species). Practical techniques aimed at manipulating a site's bird and mammal populations deserve more attention as a method to achieve restoration objectives.

S79.03 - The use of essential oils to attract fruit-eating bats and improve forest restoration

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Fruit bats are good seed dispersers that use odorific clues to locate and select mature fruits. We have already demonstrated that neotropical fruit-eating bats can be attracted to degraded areas solely with essential oils extracted from their preferred fruits. Nevertheless, this novel restoration tool is under constant development and now we have (1) compared the chemical com-

position of preferred and ignored fruits; (2) used chromatographic analysis combined with double-choice captive experiments to analyze the role of different volatile organic compounds (VOCs) in the attraction of bats; (3) identified genera of Old World flying foxes (Pteropodidae) that could be used, based on the diversity of their diet and fruit preference, in restoration programs. We have discovered that the essential oils of fruits consumed by phyllostomids share compounds, but the preferred ones can be identified by key compounds. In addition, these bats proved to be able to identify two different types of VOCs – monoterpenes and sesquiterpenes – each with a different function in bat-fruit communication. The frugivorous diet of flying foxes was found to be diverse, but *Ficus* is the most consumed fruit genus. *Cynopterus*, *Pteropus* and *Rousettus* were identified as potential models for the adoption of the restoration tool in tropical continents where phyllostomids are not present. So, at this stage of the research we were not only able to unveil some mechanisms behind bat-plant communication, but also to provide the basis for worldwide application of this forest restoration tool based on the active attraction of seed dispersing bats.

S79.04 - Inducing ecosystem services through birds and mammals in restoration

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The loss of ecological interactions is one of the most threatening setbacks affecting disturbed habitats, especially the mutualistic interaction involving frugivores and seed plants. Seed dispersal is a pivotal ecosystem service and its absence or malfunction in restored forest ecosystems can severely impair the timing and the trajectory of restoration. Numerous techniques and strategies have been proposed to accelerate seed arrival brought by frugivores in restored sites, all with their intrinsic and idiosyncratic pros and cons. Induced Seed Dispersal (ISD) is a technique that, conversely to the ones usually employed in restoration, works as seed source and not as seed landing. It consists of embedding small seeds of native fleshy fruits in the pulp of fresh bananas that are offered to frugivores in feeders attached to poles or laid on the ground. We are testing the efficacy of this technique in a young forested restored site in southeast Brazil, using one feeder on the ground and the other attached to a pole. A grid of seed traps encircles the suspended feeder. A similar sampling design was set 600 m away, where no fruit is offered, to controlling for the induced seed rain. About 5000 seeds of *Cecropia hololeuca* (Cecropiaceae), a pioneer vertebrate dispersed tree, are offered weekly in the feeder. Several birds and mammals disperse the seeds, which are collected in the seed traps afterwards. Beyond being highly cost-effective, ISD has many ecological benefits that make it a valuable tool to improving the ecosystem services provided by seed dispersers vertebrates.

S79.05 - Modeling bridges the gap between basic and applied research on seed dispersal: mammals, fruits, and oldfields in Mediterranean Spain

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Even though plant species dispersed by animals are often the same that are subject of ambitious restoration programs, there exists a marked gap between basic and applied research on seed dispersal. Because of logistic limitations of empirical approaches, we propose that modeling is an efficient approach to fill such gap. To illustrate our proposal we chose a system composed by *Pyrus bourgaeana* trees in an old-field and two seed dispersers, the red fox *Vulpes vulpes* and the Eurasian badgers *Meles meles*, in the Doñana National Park (SW Spain). Using a spatially-explicit individual-based model (called DisPear) we asked 1) how differ proportion of foxes and badgers alter the mammal-generated seed rain into the oldfield and 2) and how different ways of planting trees in an old-field alter the seed rain generated by both seed dispersers. We evaluate by means simulation experiments the effect of contrasting ‘defaunation’ scenarios and restoration strategies on the mammal-generated seed rain. Our results indicated that 1) defaunation had a strong effect on the intensity (number of seeds) and spatial pattern (dispersal distances, seed aggregation) of the seed rain and 2) that whereas planting trees in regular and random distributions largely augmented the proportion of old-field that received seeds, planting fruiting trees in an aggregated fashion had only a minor effect on the number of seed arriving into the old-field. Combining long-term field research and spatial modeling helps to bridge the gap between basic and applied research on seed dispersal.

080 Water-related ecosystem services: economical aspects

080.01 - Economic valuation of river restoration: An analysis of the valuation literature and its uses in decision-making

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We provide an analysis of existing non-market valuations of river restoration primarily in the United States and Europe. The goals of the river restoration in terms of ecosystem services are identified, as are the valuation methods used. More than two-thirds of the 38 river restorations reviewed sought to restore fish populations, including in many cases endangered species. River restorations were also undertaken to improve wildlife habitat, and water quality. While a variety of economic valuation methods were used for valuing river restorations, the majority of restoration valuations utilized survey based methods such as the contingent valuation method (CVM) and choice experiments (CE) or conjoint methods. A multiple regression analysis of these values showed that benefits per household increased significantly with the number of miles of river restored and the number of ecosystem services restored. Specifically, benefits per household rose by \$36 USD with each additional ecosystem services being restored. The highest monetary values were associated with dam removals to restore salmon migration and habitat (\$165 USD per household), well known rivers or endangered species. Nonetheless significant economic values per household were found for restoring riparian areas in desert ecosystems (\$56 per household) and for restoring degraded streams in agricultural areas. Since many of the ecosystem services of river restoration are public goods, even small values per household amount to hundreds of millions to several billion dollars a year. These values were incorporated into a variety of decision documents including benefit-cost analysis and environmental impact statements.

080.02 - Unbiased evaluation of the ecosystem services and its role in greening village economy

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The cumulative effect of catchment-wide aquatic environmental ecosystem degradation presents a hazard to human well-being and economy due to their intricate nature. The degradation effects result from various water and land use practices, which impacts the aquatic ecosystem services. Various economic sectors and humans bear the resulting risks directly, and especially marginalized communities who are reliant on aquatic ecosystem services for their livelihood. Despite our supposedly improved understanding the role of resilient natural capital, evidence of severe ecological and socio-economic degradation is evident all around us, especially in the developing economies, where for some reasons governments are not successful in the implementation of large scale command-and-control type of environmental regulations. This study provided objective evidence in demonstration of the practical value of wetlands in water security and the effects of environmental degradation on socio-economic systems. A new and objective Integrated bio-economic model was used to demonstrate the relationships between the environmental status and the economy by using production functions where the environmental indicators are used as inputs into the production of ecosystem services. It was tested in the Zaalklap wetland system, dominated by mining and industrial impact. Based on estimates done, the asset value of the Zaalklap wetland ranges between R501-R763 million, of which the water purification and waste assimilation service contributes R130-R560 million at a rehabilitation costs of R1.7 million. This demonstrates that wetland rehabilitation plays a significant role in greening the village while supporting green economy

080.03 - The costs and benefit of rehabilitation of Urban Ecosystems using Evidence-based Approach

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Over the next few decades we expect to see increasing urbanization, development of water services infrastructure, energy and electrification projects, transport infrastructure development and industrialisation in the Africa and other developing regions. It is a continuous challenge in developing countries to balance economic development with maintenance of a healthy ecosystem as it requires recognition of the inter-dependencies between the natural environment, economic stability, and social well-being. Since ecosystem services are free or under-priced, their exploitation is not considered to constitute an economic or social cost which must be weighed against the economic benefits of the production and consumption they generate.

A study was conducted develop and refine approaches and tools needed to analyse the impacts of environmental degradation on socio-economic development and also to evaluate the benefits of restoration of aquatic ecosystems services.

080.04 - Payment for Ecosystems Services in Camboriu River Watershed as an incentive tool for watershed restoration

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Camboriu Watershed is located on the northern coast of Santa Catarina state, Brazil. Two municipalities share this watershed, Balneario Camboriu and Camboriu, and both use it as their sole water supply. The municipal water company, EMASA, is concerned about the maintenance and improvement of the quality in the long term. Sedimentation, which impacts the water treatment plant, can be avoided by protecting and restoring priority areas inside rural properties in the watershed. Therefore, a law was passed in Balneario Camboriu creating the Camboriu River Water Producer Project. This law foresees the application of Balneario Camboriu funds in the neighboring municipality, Camboriu. Payments for environmental services (PES) were adopted as an incentive tool to financially compensate rural landowners who undertake conservation and restoration actions in areas of interest of the project inside their properties. EMASA allocates 1% of its revenue to the restoration projects. Soil and Water Assessment Tool (SWAT) hydrological model and IDRISI Land Change Modeler were used to prioritize the restoration and conservation intervention areas. A return on investment (ROI) analysis was carried out to investigate the financial tradeoffs for the water company to invest in "green infrastructure". Thus, the ROI study built the ground to include the watershed conservation costs into the water tariff structure, creating a sustainable financing tool for restoration, PES and all related transaction costs.

080.05 - Wetland ecosystem services after beaver reintroduction - biodiversity facilitator/conflict generator

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European beaver disappeared from the fauna of Romania at the beginning of the 19th century, due to over hunting and habitat loss. Eighteen years after its reintroduction (which was carried between 1998-2001) in Romania, beaver came to populate most inland rivers and their tributaries. In general, after the reintroduction of a species, it is necessary to monitor the newly formed population trends until its stabilization. By its ethology, beaver is known to be a species that creates and modifies wetland habitats. One of the important aspects that need to be monitored are the placement of dams because they affect runoff to the streams and also the development and formation of wetlands. Considering the category of land use adjacent to beaver colonized rivers, wetland habitat services are not always in accordance with the requirements of development needs of local communities. Given the importance of wetland habitats created by beaver, we consider it imperative to create embankment activities distribution maps, which predict future formation of wetlands. This preparation would allow us to benefit from habitat services provided by wetlands. Wetlands created by beaver behaviour have so far affected construction of highways and airports in Romania. A better understanding of the development of wetlands created by beaver could lead to reduced conflict and sustainable ecosystem benefits.

080.06 - The Economics of Ecosystems & Biodiversity (TEEB) in the Rio do Paraíba do Sul Basin (SP)

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The Economics of Ecosystems & Biodiversity (TEEB) is a global initiative to “make nature’s values visible”. TEEB main aim is to mainstream the values of biodiversity and ecosystem services into decision-making at all levels by following a structured approach to valuation. Here we show the case study of TEEB in the Sao Paulo state in the Paraíba do Sul River basin. This area is crucial for the provision of water ecosystem services and is situated in deforested and highly fragmented biome of Brazilian Atlantic Forest. We will present refined land use maps of the area and valuation of ecosystem services for three alternative scenarios: (i) business as usual (no restoration), (ii) Forest Code compliance, (iii) Forest Code Compliance under CRA market (Brazil’s Market for Trading Forest Certificates). These scenarios were chosen after extensive field survey study that also gave insights into perception of ecosystem services by the local population (both producers, N = 112 and other stakeholders). Water was identified the most important ecosystem service by all surveyed actors. With respect to forest, most of the producers (78%) claimed to have it on their properties, and 48% keep it to comply with the law. Lack of qualified labour (65%) and lack of government support (50%) were pointed out as the principal barriers to more sustainable land use in the basin. The results presented in this study have direct applications in decision-making towards more sustainable land use in the region and elsewhere.

081 Remote sensing: application in restoration planning and monitoring

081.01 - The ephemerality of regenerating forests in southern Costa Rica

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Forest age following disturbance is a strong predictor of many social and ecological values, yet regenerating forests are frequently converted to agriculture or other land uses before these values recover to reference levels. Regenerating tropical forests, for example, may be deforested again before they regain their maximum carbon sequestration or provide habitat for sensitive forest species. Here, we used a time series of aerial photographs (1948-2014) to evaluate multi-decadal longevity of regenerating premontane forest across a landscape in southern Costa Rica (~530 sq. km). Our analysis indicated that these regenerating forests had relatively short longevities. Of forests that began regenerating in 1948-1960, 55% were deforested before they were 33 years old, 73% before they were 50 years old, and 91% before they were 67 years old. These percentages were relatively consistent for more recent cohorts of regenerating forests, and for forest patches of varying sizes, indicating that ephemerality may be a general attribute of regenerating forests in this region. Variance in forest longevity from one patch to another is attributable to stakeholder preferences, environmental constraints, and the influence of government policies; accordingly, a predictive model based on these factors could be useful for prioritizing restoration efforts. Additional historical analyses are needed to determine whether short durations are typical of restored and naturally-regenerated secondary, tropical forests.

081.02 - Remote sensing of degraded tropical forest trajectories in the Brazilian Amazon: New insights for landscape restoration

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There is a growing consensus that integrating production and conservation is an efficient strategy to achieve conservation goals. However, in tropical areas dominated by agricultural activities, forested landscapes are often represented by a mosaic of degraded and fragmented forests. To yield high conservation benefits, restoration of degraded forests is a priority. Forested landscapes involved in land use and cover change dynamics have been shaped by agricultural and forestry activities. Many studies have proved that deforestation and forest degradation can be identified but no studies focus on understanding the determinants of forested landscape construction over time and space. This study addresses that gap by analyzing landscape trajectories within a range of deforestation pioneer fronts of the Brazilian Amazon in Pará and Mato Grosso state. A first outcome is to reconstruct disturbed forest structure history from Landsat time series and derive forest degradation metrics. Then, we will present how this previous information can be implemented into a landscape dynamics model and identify varied patterns of forest anthropization. Consequently, focusing on landscape trajectories provides better knowledge on the composition, structure and temporal evolution of degraded forests. This offers new perspectives for restoration strategies of degraded forests towards multifunctional forested landscape.

081.03 - Use of Remote Sensing to Monitor Native Vegetation Restoration Projects

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One of the bottlenecks to the success of large-scale native vegetation restoration is the difficulty of obtaining optimized and reliable data, especially in the monitoring stage. Current protocols require a high demand for field data collection, which makes projects more expensive. This study aims to develop a methodology to monitor extensive restoration areas in state of Espírito

Santo, Bahia and Minas Gerais, using satellite images. We obtained SPOT and Pleiades images, with spatial resolution of 1.5 m and 0.5 m, respectively, and performed a supervised classification. A pilot restoration area of 62 hectares, to be replicated over approximately 4,700 hectares, was used to compare canopy cover obtained through classification using Pleiades (2014) and SPOT (2016) images. In the sampling, the reflectance of the targets was considered in relation to their similarity and heterogeneity. Then, the Maximum Likelihood classification was applied and the median spatial filter eliminated classification noise. The Kappa Index indicated an efficiency of over 90% of the classifier. In the pilot area, we found 22% (13.8 ha) of canopy cover using the SPOT image and 31% (19.2ha) with Pleiades. The mapping demonstrated the effectiveness of qualifying restoration areas, allowing the development and replication of monitoring protocols in other projects in Brazil. Despite the different acquisition dates of the satellites images, the low difference (9%) in the coverage of the two images indicates, preliminarily, the acceptable effectiveness of lower resolution images (SPOT) for monitoring, thereby reducing costs in restoration projects.

081.04 - Zoning of the Mato Grosso state natural regeneration potential

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At COP21 in Paris, the Mato Grosso State government has taken the commitment to restore 2.9 million hectares of degraded areas until 2030 through the state program Produced, Conserve and Include (PCI). However, the high cost of restoration is one of the main challenges to achieve this goal. Our study seeks to identify where are the best opportunities to restore degraded land at low cost and contribute to achieve the PCI restoration goal. For this purpose, we classified the state according to its Self-Recovery Potential (SRP). The analysis was based on the identification of regions with high SRP through a set of indicators, based on concepts from landscape ecology, using GIS analysis and specialists' knowledge. We combined layers of high SRP and low agricultural capacity pasturelands to avoid potential conflict with land use for crop, also the layer of areas where regeneration is already ongoing to indicate the restoration opportunities. Result shows that there are 2.7 Mha of pasturelands with high NRP and 2.6 Mha of areas where regeneration is ongoing currently. Finally, we present different approaches to zoning the more favorable regions for natural regeneration, grouping the areas with high SRP by watershed, municipalities and proximity to large forest remnants. This mapping indicates that there is enough area with high SRP and low agricultural capacity to meet the restoration goal of the PCI program. These analyses can support public and private agents to guide the restoration efforts in a more assertive way increasing the cost-effectivity of the restoration projects.

081.05 - Habitat availability improvement from natural regeneration and spatially planned restoration

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Allowing the regrowth of secondary forest through natural regeneration is recognized as a key strategy to achieve large scale restoration goals. However, it is necessary to understand how natural forest regeneration can improve habitat availability for forest dweller species. In this sense, we aimed to understand how habitat availability can be maximized, considering different strategies to allocate restoration efforts. We first analyzed habitat availability improvement due to natural forest regeneration, in the last 50 years, in different landscapes of the Atlantic Forest. Secondly, we adopted a simulation approach to analyze the improvement of habitat availability due to different restoration strategies considering: (i) different species dispersal capabilities, (ii) initial habitat amount in the landscape, and (iii) the dynamics of landscapes during restoration implementation, i.e., the changes in habitat availability as new areas were restored. Natural regeneration was not able to increase habitat availability in all landscapes due to offsets promoted from deforestation or to changes in habitat configuration. Habitat availability improvement was maximized when restoration simulation was planned for a specific dispersal distance and considered the landscape changes promoted by each restored area. The adoption of a dynamic spatial approach was crucial to identify the ideal sequence of restoration. Allowing natural regeneration in the landscapes can contribute to increase habitat availability in fragmented landscapes. However, it is essential to spatially plan the restoration actions and identify the ideal areas to conduct natural regeneration and combine with other restoration strategies in order to maximize the benefits for biodiversity.

S82 Invasive alien species and restoration ecology: causes and consequences of invaders, impacts of removal, interactions with native communities and insights for the future

Organizer: *Maurício Cruz Mantoani*

S82.01 - Governmental procedures and the state of art about invasive alien species in Brazil

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The Alien Invasive Species (AIS) problem started to be more consistently treated by the Brazilian government only after 2001. In 2005, the Environmental Ministry organized the first Symposium on Invasive Species and in 2006 the First National Report on AIS was published. In 2009 it was published the National Strategy about AIS and with it an official permanent technical council of specialists was established. The National Strategy brought up guidance on preventing and mitigation of AIS impacts; planning and execution of actions on prevention, eradication, containment and control; articulation of governmental agencies, civil society and international cooperation. CDB Aichi Biodiversity targets endorsed by Brazil included: implementation of the National Strategy; creation of a National Policy and Action Plans; publication of official lists; and the establishment of a target to control three AIS by 2020. The AIS selected as main targets were: *Tubastraea tagusensis* and *T. coccinea* (sun coral); *Sus scrofa* (wild boar); and *Limnoperna fortunei* (golden mussel). No plants were considered as priority targets even though the conservation of protected areas, specially in open environments, is highly threatened by invasive African grasses, where these grasses are also the main problem for restoration efforts. Currently a national project funded by GEF is under final planning before implementation with the aim to establish a system for AIS early detection and eradication. In practical terms, there are few rules and practices being implemented in Brazil in order to control AIS, only isolated examples that deal with local cases, invasive plants being mostly neglected.

S82.02 - State and Transition Models: science giving support to management decisions in Pine invasion over cerrado grasslands

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Pinus is a genus of tree species native to the Northern Hemisphere, comprising 111 species of which at least 22 are invasive in different regions, mostly in the Southern Hemisphere. The invasion often follows pine introduction for forestry, as occurred in the Cerrado (Brazilian savanna). Invasion by slash pine (*Pinus elliottii* Engelm var. *elliottii*) has caused huge losses in plant diversity. Additionally, when open and highly diverse cerrado grasslands turn into dense and dark pine forests, the rich ground layer is replaced by a thick needles layer. We developed a State and Transition Model (STM) to represent the pathways of pine invasion over cerrado grasslands and to indicate how management interventions can revert the process. The STM comprises the different ecosystem states during the invasion process and presents the factors influencing the transitions between states. All input information was provided by previous studies on invasion ecology and on experiments of eradication techniques. We described how the invasion leads to transition between ecosystem states by changing ecological filters and assembly rules that regulate species composition and ecosystem structure. The STM clearly indicates factors behind the transition from the pristine ecosystem to the invaded condition, step by step, arising as a useful tool to support management decisions aiming at pine invasion control.

S82.03 - Removal of invasive alien species and effects over mammal communities

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Predicting the ecological behavior of a species in a new environment is difficult due the interaction of biological, environmental, and anthropogenic factors. This study aims to present the effects of removal of invasive alien species and the effects over mammal communities in a effort to restorate forest clearings invaded by *Artocarpus heterophyllus* L. (Moraceae) commonly known as jack fruit tree. Jack fruit tree is a large evergreen late successional shade-tolerant species, that exists in three contrasting light conditions which gives it perfect conditions to grow and spread on the brazilian atlantic forest in the Rio de Janeiro State. After an experiment of control of jack fruit in 10 plots of 6.400 square meters each, there was evaluated the response of mammalian community in the period immediately after the treatments. Additionally, another 8 plots with absence of jack fruit trees were monitored. The population of small mammals was positive correlated with the advance of the invasion of jackfruit. However, after the controlling experiment and with the trees dieback, the effects on the community structure indicated that the densities and abundance shows a tendency of similarity to results obtained for congeneric species in less anthropized sites with absence of jackfruit. The changes of local populations of potential seed dispersers can be a positive feedback for the restoration of the invaded areas by the lower propagule pressure and the increase of native seeds brought by these mammals, which now are eating native fruits and dispersing seeds from the surroundings.

S82.04 - *Gunnera tinctoria* invasions in Ireland: Impacts on greenhouse gas emissions and soil carbon and nitrogen and the effects of removal

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Recent evidence indicates that plant invaders can alter soil attributes and increase greenhouse gas emissions. To assess the impacts of *Gunnera tinctoria* Molina (Mirb.) invasions on greenhouse gas emissions and on soil carbon and nitrogen, comparisons were made with uninvaded grasslands and invaded areas subjected to mechanical removal and herbicide application on Achill Island, Ireland. Invaded areas had a higher total soil carbon concentration (TOC) in the top soil layer (5-10 cm) (average of 14.02 %) compared to uninvaded areas (average of 10.12 %), but only during winter. No differences were found among the other soil layers (20-25 cm and 50-55 cm) during winter and no differences were found for any soil layer examined during the summer. This suggests a seasonal input of near-surface carbon that is lost from the system. In addition, despite there were also no differences in total nitrogen, during autumn invaded plots had a higher nitrate concentration (average of 13.87 mg N/kg soil) than uninvaded grasslands (average of 5.13 mg N/kg soil). To date, whilst there were no differences in CO₂ or CH₄ emissions amongst the treatments, prior to removal invaded areas had over an order of magnitude higher N₂O emissions (average of 2,052 µg N₂O m⁻² h⁻¹) compared to uninvaded grasslands (average of 124,3 µg N₂O m⁻² h⁻¹). After removal, there were no differences in N₂O emissions among the different treatments. This suggests that *G. tinctoria* invasions may have a minor impact on soil carbon and nitrogen but have a major impact on N₂O emissions.

S82.05 - The impacts of invasive species management on ecological resilience in a sensitive community

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Invasive species are thought to be one of the great threats to global biodiversity. As a result, there are enormous resources spent on controlling and removing invasive species annually. Some argue, however, that the gains from such management do not meet the expense; e.g. when removal of one invasive creates a 'weed-shaped hole' immediately filled by another. We studied the impact of invasive species control on the resilience of Garry Oak ecosystems in British Columbia. Garry Oak meadows are diverse communities that have been largely lost to land use change. British Columbia represents the northern-most distribution, and ecological resilience here may be indicative of long-term Garry Oak meadow persistence globally. Using a broad range of

functional trait data, we classified vegetation species into both a general functional group and a functional-response group. We then tracked changes in functional redundancy and response diversity over ten years in urban and rural parks. Working with community members and managers, we also estimated invasive species control levels in each park for the same ten years. We found that invasive species control did maintain levels of functional redundancy and response diversity; however, this pattern was often weaker than the index of human use (calculated as surrounding road density) and connectivity of each patch.

084 Using fauna as indicators in restoration ecology

084.01 - Assessing change in ecosystem restoration: Composition of terrestrial vertebrates and vegetation as indicators

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Assessment of restoration projects is essential for adaptive management and for justifying their costs, but comprehensive monitoring and evaluation are not always incorporated into projects. We developed a cost-effective monitoring program for lands managed by 5 Native American tribes in northeastern Washington and adjacent Idaho. Key ecological objectives of restoration efforts are that the restored area (1) has an assemblage of species characteristic of a reference ecosystem that provides appropriate community structure, and (2) consists largely of indigenous species. We established 24 reference points representing the best extant representatives of 8 habitat types, and 83 sampling points on 39 restoration areas. Composition and structure of vegetation, and composition and relative abundance of small mammals, birds, and larval amphibians were monitored over 3 years for reference points and at 5-year intervals on restoration sites. Dissimilarity matrices that incorporated relative abundance (Chao-Jaccard) were calculated to compare lands undergoing restoration to the reference conditions for each habitat. Non-metric multidimensional scaling was used to visualize the relationships of restoration to reference sites for each habitat type. Reference sites showed much lower variation both spatially and temporally than restoration sites. Sites sampled early in the restoration process indicated that multiple trajectories toward the reference condition were likely. Small-mammals and birds appear to be appropriate indicators of change for habitats such as shrub-steppe where there are clear linkages with herbaceous vegetation. For habitats subject to disturbance (e.g., flooding), local extinction and colonization events can alter species composition and abundance and move habitats away from reference conditions.

084.02 - Restore it and they will come: trap-nesting bees and wasps communities are influenced by restoration of riparian forests

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There is growing evidence of restoration success for plant communities of riparian forests. However, little research has been done on the associated invertebrate community. We tested whether restoring plant communities is sufficient for restoring the taxonomic composition of trap-nesting bees and wasps in four restored riparian forests, compared to a reference site in Southeastern Brazil. Patches of riparian forest were restored since 10 to 20 years, immersed in an agricultural landscape. We predict that trap-nesting bees and wasps abundance, species richness and community composition of the riparian forests being restored will converge to the "target" reference over time since restoration and proportionally to the width of the fragments (30 and 100 m) and habitat complexity. We also predict that size of the restored patches will influence trap-nesting bees and wasps' abundance, species richness and community composition. Forests at 20 years after restoration were characterized by high species richness and the community composition became more similar to the reference than in the youngest forest. Specialist bee taxa were persistently less abundant on the riparian forest within 10 years after restoration causing persistent differences in species composition, even on the larger fragments. Our results indicate that, although restored forest patches were relatively small and scattered in an agricultural matrix, they provide suitable habitats for recolonization by trap-nesting bees and wasps' community assemblages. Hence, restored riparian forests can be considered important habitats for invertebrates, increasing local biodiversity and, possibly, restoring some of the ecosystem services they provide.

084.03 - Fauna functional groups used to evaluate the successional pathways in a semideciduous seasonal forest in restoration process

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In restoration process the aim is to re-establish ecological interactions that had been lost whereas they are responsible for the successional pathways. This study evaluated the dynamic among vegetation, birds and medium and large-sized terrestrial mammals in a permanent preservation area under restoration process focusing on fauna functional groups. The study area belongs to Instituto de Pesquisas e Estudos Florestais - IPEF (Piracicaba, Brazil) where a high diversity saplings planting was held in 2006. The monitoring was carried out from March 2010 to February 2017. Fauna data were obtained monthly and the phytosociology every two years. The functional groups were defined according to body mass, diet, habitat, stratum and nest type. Our results showed an increase in basal area (11.2 to 22.5 m².ha⁻¹) demonstrating evolution in forest structure. Yet, there was a decrease in tree species richness together with an increase in early successional species density, which can influence the ecosystem's ability of self-maintaining over time. A total of 127 birds and 16 mammal species were recorded, comprising 29 and 7 functional groups, respectively. In 2014, due to a severe drought, the understory plant density just as the amount of mammalian functional groups and bird species richness decreased. In the past two years, functional groups of higher ecological demands (frugivores, ground-dwelling insectivores and predators) have been registered, which might indicate that a more complex and well-structured fauna community is taking place in the area and the ecological succession in restoration process is moving forward.

084.04 - Litter arthropod fauna as parameter to evaluate ecological restoration in the Brazilian Ombrophilous Dense Submontana Forest

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The use of entomofauna and other arthropods is not a common method to evaluate ecological restoration in Brazil. However, plant- insect interactions may be useful indicators for identifying different the successional phases during the restoration process. In this study, we surveyed the litter fauna from different degraded pasture areas under restoration with 5 different nucleation techniques and native seedling plantings in the Serra do Itajaí National Park located in the Santa Catarina state of southern Brazil. We compared the litter fauna from a surrounding preserved forest and natural regeneration area with our restoration site to identify arthropod diversity during this process. Several ecological indices, e.g., species richness, diversity, abundance, similarity and richness estimators were used to compare the areas. Arthropod fauna was sampled with pitfall and Berlese funnel traps bimonthly since 2014 and will continue for the duration of the project. All groups were identified to Class, Order and Family levels. Results from 2014 - 2016 show that the Class Collembola is the most abundant group in pasture areas and decreases in abundance when herbaceous plants and some shrubs appear. Beetles in the families Ptiliidae and Staphylinidae (Coleoptera), are potential indicators of advanced vegetational succession. Bark beetles in the subfamily Scolytinae, a unique group that was identified to species level, are associated with woody species material deposited on the litter surface.

084.05 - Juvenile fishes as functional describers of ecological rehabilitation in a gravel bed river

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The river Meuse has been heavily impacted by channelization but in the middle reach a 48 km long free-flowing stretch is still present. This part of the river however has been impacted by gravel extraction and the construction of dykes as well. In order to restore the contact between the summer and winter bed of the river, nine new riffles have been constructed in the period 2006-2009. These riffles have been evaluated using point abundance sampling by electrofishing of young of the year fishes in six

sampling campaigns in 2010-2011. The impact of the new riffles has been compared with natural riffles and results from previous samplings on the same locations five years before to the restoration efforts. Measurements show that the new riffles are much steeper than the natural riffles. Over this ten-year period the number of species reproducing in this part of the river has increased and apart of the typical rheophylic species also juveniles of limnophylic or eurytopic species are present in low numbers. The results clearly indicate the functionality of newly built riffles as habitat for juvenile rheophylic fish as well as the importance of tributaries for spawning and habitat for juvenile fishes inhabiting the main river. In the future, additional gravel suppletion is needed and will have a positive effect on the high turbulence in the new riffles and suitability as habitat for juvenile fish.

S85 Seed-based Restoration: Innovations, Opportunities and Challenges - Getting Seeds (part 2/2) and Using Seeds (part 1/2)

Organizer: Kingsley Dixon

S85.01 - Ecological restoration hurdles to use rarely cultivated plants; Developing reliable seed production technology

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The use of seed for ecological restoration assumes adequate supplies are available. When adequate seed supplies cannot be collected in the wild, they need to be cultivated and harvested. Commonly cultivated crops and ornamental plants have well defined seed production practices. Infrequently cultivated species present numerous challenges to overcome. The best timing for planting and placement of seeds in the soil may be unknown. Seedling survival can be compromised or promoted by various factors. Plants may present seed production problems, once many plants of the same species are grown in close proximity. In the wild these problems may have been mitigated by the plants not being numerous or being widely dispersed. Weeds, insect pests, and diseases may need to be controlled to allow the planted species of interest to thrive. Soil nutrient and water needs for seed production must be met. Most plants require pollination for seed production, some requiring specific pollinators. Specific harvest practices, harvest timing, and seed cleaning must be developed for each species. Experimentation to develop stand establishment and irrigation technology for seed production of rarely cultivated plants will be described in detail.

S85.02 - Addressing global seed challenges in seedling nurseries

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Globally, forest and rangeland restoration using native species often starts with the procurement of seed. Whether using direct seeding or seedlings, a frequent challenge is to obtain seed that is of appropriate origin and biological quality to meet the needs of the project. For those projects that employ the use of seedlings, the Target Plant Concept provides a framework that promulgates a holistic process from seed selection through nursery culture to outplanting and post-planting practices. Using examples from contemporary nursery projects in Armenia, Haiti, Jordan, Lebanon, Togo, and the United States, this presentation focuses on how forest and native plant nurseries procure and manage seed, highlighting potential roadblocks and possible solutions. By covering a scale from small, rural nurseries through to large, commercial facilities, a range of options will be discussed with the aim of presenting opportunities for production of high quality seedlings that meet the objectives of the restoration project. Whether working locally or across broad regions, some of the challenges faced are in fact quite common and include seed procurement and handling issues, appropriate consideration of population and landscape genetics; lack of propagation protocols or ecological knowledge; issues related to nursery construction and/or location; as well as species identification, training, overcoming language barriers, and on-going project financing.

S85.03 - From dormancy to establishment: Addressing key bottlenecks to plant recruitment in a restoration context

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With more than half the world's ecosystems classified as degraded, the need for restoration at a landscape-scale is now beginning to be broadly recognized. Restoration efforts rely heavily on large quantities of seed, which are either produced by commercial growers or wild-collected and require substantial labor and financial inputs. Research has shown that the majority of seeds (ca. 90-95%) used for restoration fail to germinate or emerge. Globally, more than half of all native angiosperms produce seeds that exhibit seed dormancy at maturity. Mitigating key limitations to plant reestablishment associated with early life plant traits (i.e. dormancy, germination, emergence) as well as minimizing edaphic and environmental limitations to recruitment and survival can significantly increase the effectiveness of seed-based restoration. To address this issue systematically, we discuss a three-stage conceptual framework that can be used to guide strategies for improving the likelihood of seed germination and seedling establishment in situ. The framework involves (1) the classification of seed dormancy in region-specific restoration species, (2) the application of a corresponding treatment to alleviate dormancy, and (3) the identification and use of seed enhancement technologies (e.g. seed priming, coating, chemical stimulants, etc.) to further improve seedling emergence and establishment tailored to a "target restoration" scenario. We demonstrate the global applicability of this framework through examples from the Pilbara (Australia) and Great Basin (USA) ecosystems.

S85.04 - Seed enhancement for ecological restoration

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"Ecological restoration at the planetary scales expected will demand a new approach for improving the reliability and effective field application of native seed. Timely and successful seed germination and seedling emergence are core to ensuring plant establishment. However, many issues such as limited seed availability, low seed quality and viability, seed dormancy, ecological barriers, seasonal impacts, and logistical impediments in seed deployment have so far hampered the success of seed-based restoration. To overcome these impediments, this study evaluated a range of agricultural seed enhancement technologies adapted and customised to native species. The study investigated four common and widespread grass species native to Australia which are usually 'un-treated' in their deployment to field restoration sites. We developed a framework for native seed enhancement that takes into consideration key steps in the seed supply chain:

- Seed processing: if external structures such as florets limit seed physical/physiological activity and seed handling. Their removal was evaluated using a range of different techniques like mechanical abrasion, flash flaming and acid digestion.
- Seed enhancement with germination promoters and growth regulators.
- Seed coating to improve seed handling/sowability and as a carrier for seed protectants and promoters.

Seed processing techniques, especially acid digestion, significantly improved germination and seed handling, compared to the untreated seed across the four species. Seed enhancement and coating approaches showed that improved flowability occurs when seed is coated/pelleted. This framework represents a useful tool for researchers and restoration practitioners and could lead to a more effective and efficient use of seed in restoration."

S85.05 - Producer's Perspective on Native Grass and Forb Seed Production

JERRY BENSON; MATTHEW BENSON; NANCY SHAW

"Better Seed Through Genetic Preservation", has been the motto for our firm from the start. Shifting our focus from an agronomic paradigm to an ecological one creates success on a scale in restoration projects never experienced. Grasping the difference in purpose and genetics between the two ideas is critical for the producer. End-users and producers must have a unified communication chain rather than a disintermediated commodity production process; separating production from the restoration project will not work. The final pieces of this complex puzzle of restoration now must find market functions that can support the technical weight of a whole-system approach, not yield per acre, not largest restoration site size, but sustainable and robust plant communities into the future.

086 Carbon sequestration in ecological restoration

0 86.01 - Ecosystem carbon sequestration through restoration of degraded lands in North Eastern India

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This study evaluated the ecosystem carbon(C) stock for predominant land uses converted from forest in North eastern India (NEI) to advance the scientific knowledge and minimize the anthropogenic emissions from land use change (LUC). Field experiments were conducted over two year period on six predominant land uses including: (i) less disturbed forest (LDF), (ii) disturbed forest (DF), (iii) rubber (*Hevea BRAZILIensis*) plantation (RP), (iv) Areca (*Areca catechu*) plantation (ArP), (v) pan (*Piper betle*) jhum (slash and mulching) agroforestry (PB), and (vi) *Imperata* grassland (IG) for representative sites in NEI to assess changes in ecosystem C stock with progressive (e.g. DF to PB) and retrogressive(e.g. LDF to DF) LUC and management. Ecosystem C stock was the highest for LDF (300 Mg ha⁻¹) and the lowest under IG (110 Mg ha⁻¹).The ecosystem C stock under PB and IG was 11 and 63%, respectively, lower than that under LDF. The gain in ecosystem C stock was 114 and 12% for RP and ArP, respectively, when IG was considered as the control. The LUC and management of DF through PB and RP showed the ecosystem C sequestration rate of 5 and 4 Mg ha⁻¹ yr⁻¹, respectively. Similarly, the ecosystem C sequestration rate was 0.5 and 4 Mg ha⁻¹ yr⁻¹, respectively, when IG was converted into ArP and RP. Therefore, restoration of degraded lands (viz. DF, IG) through RP and PB enhanced ecosystem C sequestration rate and reduced anthropogenic emissions from LUC.

0 86.02 - Comparison ecosystem carbon stock and soil carbon source between two restored mangroves with different species

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Knowledge on the soil organic carbon (OC) stock and its sources is important to understand the carbon processes and carbon sequestration benefit following mangrove restorations. The present study compared the ecosystem OC stock between 13-yr-old restored mangrove forests of two species, *Kandelia obovata* and *Aegiceras corniculata* with a same plantation density. The contribution of mangrove derived OC to soil OC was also quantified based on the multiple $\delta^{13}C$ analysis. Mangrove restoration enhanced the OC accumulation in soil and the OC stocks increase from 4.20 kgC m⁻² in the top 60cm soil at the mud flat as beginning stage of restoration, to 4.50 kgC m⁻² and 4.23 kgC m⁻², respectively at the *A. corniculata* and *K. obovate* sites. However, arborea *K. obovate* had a significantly higher biomass OC stock than that of shrubby *A. corniculata*, resulting in a higher ecosystem OC stock. Soil profiles in the three sites showed that soil OC concentration and density decreased with soil depth and were higher at the *A. corniculata* sites, while the differences between the two mangrove species were more substantial at the top 30cm soil. $\delta^{13}C$ analyses revealed that mangrove-derived OC contributed a higher proportion to *A. corniculata* soil OC than to *K. obovate* soil OC (67.7% vs. 54.5%) while suspended particular organic matter dominated the soil OC at the mud flat. The results indicated that the two mangrove species have different benefit to ecosystem carbon sequestration, which should be considered in the mangrove restoration.

O 86.03 - Monitoring soil carbon sequestration in land reclamation and ecological restoration

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Organized revegetation activities began early last century by the Soil Conservation Service of Iceland (SCSI). To date about 2000 km² or more than 2% of the island have been revegetated using various species, including introduced Nootka lupine. However, the focus has increasingly been on ecological restoration approaches since the 1980s. Revegetation activities that can be classified as ecological restoration aim at recovering degraded, damaged or destroyed ecosystems by accelerating local ecosystem processes. Ecological restoration increases biodiversity and resilience of restored ecosystem, and carbon is sequestered in both vegetation and soils. Evaluation of ecological restoration projects is critical for continuous improvements of restoration measures, and in that monitoring has an important role. In 2007, a monitoring project started aiming at determining carbon sequestration in SCSI revegetation areas initiated after 1990. Over 600 plots are now actively monitored for changes in vegetation cover and species composition and changes in soil C and N. In this talk we compare carbon accumulation in soils across different interventions and conditions. Results suggest that there is a difference between degradation stages in terms of C sequestration in the soil. Highly degraded areas, where ecosystem functions are severely dysfunctional, sequester at lower rates than other sites and rates differ between different management inputs. This suggests that there are ecological thresholds present which can be overcome by different restoration inputs and adaptive management approach. These thresholds must be identified for optimizing outcome of ecological restoration and to maximize use of resources for soil carbon sequestration.

O 86.04 - Carbon fixation in the biomass of the Protection Strip of Itaipu reservoir in Brazil

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The Protection Strip along the Brazilian bank of the reservoir of Itaipu Hydroelectric Power Plant is a large scale restoration project. It is 1,395 km long, stretching from Foz do Iguaçu until Guaíra cities, in the West of Paraná State (Brazil). It has a total area of 26,475 ha and counted on the planting of 22,541,381 saplings of 110 species belonging to different succession stages. Through analytical study of field data available in the specialized literature (silvicultural trials with saplings of species found in the municipalities within the Strip, thus regarding the same type of soil and climate), and by using theoretical formulations in order to quantify the amount of carbon stored up in the whole aerial biomass (amongst them, Brown's allometric relations for dry, moist and mixed climates) and their roots from the beginning of the plantings in 1979 up to 2016, it was computed that the Brazilian Protection Strip has already fixed 42,621,770 t CO₂ in its biomass, which yields an average fixation rate of 39.04 t CO₂ ha⁻¹yr⁻¹. Only in 2016, around 2,427,760 t CO₂ were fixed by the vegetation. Ultimately, it was inferred that the Protection Strip has carbon fixation potential up to the year 2052, when 194,069,174 t CO₂ might have been withdrawn from the atmosphere. Such results are annually updated in order to comprise the Sustainability Report of Itaipu, and evidence the importance of large scale restoration as an ecosystem service.

O 86.05 - Vegetation succession trajectories in revegetation areas in Iceland were influenced differently depending on revegetation methods

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Organised revegetation activities began early last century by the Soil Conservation Service of Iceland (SCSI) and have since the 1980s focused increasingly on ecological restoration. Ecosystems in Iceland are in general greatly degraded, often eroded, due to the continuous impact following the human settlement in the 9th century. Revegetation activities that can be classified as ecological restoration aim at recovering degraded, damaged or destroyed ecosystems by accelerating local ecosystem processes. Evaluation of revegetation projects is critical for continuous improvements of restoration measures, and in that monitoring has an important role. In 2007, a monitoring project started aiming at determining carbon sequestration and successional trajectories in SCSI revegetation areas initiated after 1990. Over 600 plots are now actively monitored for changes in vegetation cover and species composition and changes in soil C and N. Here we focus on successional trajectories in those areas and relate them

to carbon sequestration. Revegetation activities enhanced species richness; however the increase varied depending on methods with the fewest species occurring in lupine plots but more species in fertilised plots with and without sown grasses. Rate and direction of vegetation succession and carbon sequestration were also greatly affected by revegetation activities. Our results suggest that functional ecosystems can be developed through revegetation but not all methods ensured favourable successional trajectories for ecological restoration. Hence we identified possible win-win situations for carbon sequestration and ecological restoration, but also a possible conflict between revegetation measures for mitigating climate change and biodiversity.

O 86.06 - The role of riparian zone restoration in achieving Brazil's greenhouse gas commitments

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Forests, especially in the tropics, are considered the most important carbon sinks globally. Carbon emitted by land-use changes in tropical regions by clearing forests for agriculture, timber and pasture are the second largest contributor to global greenhouses gases (GHG) emissions. With forest conservation and recovery playing a central role in the Brazilian commitment to reduce GHG emissions, it is important to assess how recent changes in the Brazilian Forest Code (BFC) alter the obligations of restoration and, consequently, the carbon stock. By assessing this, the government can strengthen its capacity to incentivize landholders to do forest restoration through programs focused on the regular or alternative carbon market (REDD+), Payment for Ecosystem Services (PES), or similar initiative. We ran the InVEST model of Carbon Storage and Sequestration to calculate the difference of carbon stock between the years 2002 and 2010, in Santa Rosa de Lima, SC, Brazil, and simulated a scenario with restored riparian zones to calculate carbon sequestration. Even with limitations and fragilities of the model, the results indicate that 2/3 of the carbon emitted between 2002 and 2010 can be sequestered just by restoring riparian zones. Our results show that the restoration of riparian zones, in compliance with the New BFC (2012), can make substantial contributions towards meeting the Brazilian government's greenhouse gas commitments: reductions of 37% and 43% by 2025 and 2030 respectively.

S87 Institutional arrangements fostered by the Brazilian Forest Service (SFB) to support initiatives for restoration of rural degraded areas in Brazil. - Subsection 3

Organizer: Magna Cunha Dos Santos

S87.02 - The Environmental Regularization Program of the State of Acre and forest landscape restoration

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The Environmental Regularization Program of the State of Acre (PRA ACRE) aims at promoting rural environmental regularization, forest landscape restoration and a secure legal framework.

The Brazilian goal for forest restoration set by the Climate Change Plan is 12 million hectares, and a fundraising effort on national and international levels is underway. In addition, the State of Acre has built its own Environmental Services Incentives System in recent years.

The implementation of PRA ACRE and the restoration goals are integrated into Acre's environmental services and greenhouse gas emission reduction agenda, as well as into its contribution to the national goals.

Rural Environmental Registry data analysis shows that over 60% of all properties in Acre have forest liabilities, corresponding to over 300,000 ha, that are classified as: 100,000 ha of Legal Reserves from medium and large properties; 70,000 ha in Permanent Preservation Areas, and 135,000 ha in areas deforested after 2008.

The State of Acre has already built forest technical parameters and legal framework to ensure the implementation of restoration initiatives, in accordance with the forest legislation.

The main barrier to forest landscape restoration models with potential complementary income generation lies in the long-term horizon needed to achieve economic returns.

A combination of forest development with revenues anticipation and adequate loans can generate not only a revenue stream but also savings, that can be withdrawn at the time of forest harvest, at a volume that is capable of aggregating income for the producers engaged.

S87.03 - Challenges to restoration and the Environmental Regularization Program (PRA) in Bahia State, Brazil

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Bahia State faces the challenge of the Environmental Regularization Program - PRA and Restoration on a large scale in 3 Brazilian biomes (almost 11 million ha of Atlantic Forest, 15.3 million Cerrado and 30.5 million Caatinga). Our maps of priority areas for biodiversity include the identification of the most relevant areas for restoration, considering ecological relevance, recharge of aquifers, position in relation to the main water reservoirs, the hydraulic network and springs. Also, Bahia State has the largest contingent of Family Agriculture in the country, with 750,000 families, which brings greater challenges to public policies. Without public support there will be few restoration projects in family agriculture. By reconciling ecological restorations with the economic-productive dimension, we can increase the interest of these groups for restoration with agroforestry systems and low-cost models. Like all northeastern Brazil, Bahia has a great deficit in the structuring of the restoration supply chain, from seed collecting to the seedling production and qualified technical assistance offer in large scale. Most of our nurseries are not registered with RENASEM and most of our restorations are made from seedlings produced from seeds acquired in other States. Bahia Government is investing in knowledge development for restoration, through Restoration Reference Centers per biome and a Restoration Manual that typifies the degraded areas and points out specific protocols. From the Manual we develop de-

cision-making flows considering the contextual aspects (distance of fragments, consolidated area, family farming, biome, etc.) that help to choose the best protocol of restoration.

S87.04 - Methodologies of restoration and monitoring Environmental Regularization Programmes in the States of Brazil

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The first step of the legal decision-making framework is to protect areas registered to be restored in CAR against further human-mediated disturbances. Decisions regarding the restoration method are only made after three or four years, respectively, in four states in Brazil, with different level of expression of natural regeneration to increase the reliability of restoration methods prescription. Then, passive or active restoration approaches can be adopted depending on the level of spontaneous regeneration of native woody species in the degraded area e in the landscape. If a passive restoration approach is adopted, farmers have to re-assess natural regeneration to confirm that the selected approach was appropriate; if natural regeneration is not sufficient to kickstart forest regeneration, the restoration approach has to be changed to active. Once a restoration method is implemented and confirmed, monitoring has to be done at the 7th, 13th, 19th and 20th years following implementation and reports have to be presented to the state environmental agency. In each of these monitoring periods, restoration corrective actions shall be implemented to correct the ecological trajectory of the forest. Differently than previous legislations, in which environmental secretariats had a direct influence in restoration with a lot of documents, time and, sometimes, bribes to authorize project, the new legislation is more pragmatic and focused in the role of government as a provider of a transparent legal environment for project managers, to determine which restoration outcomes are expected, and to enable public agents and farmers to apply the legislation.

S87.05 - WebAmbiente- a virtual platform with native species, restoration strategies and field experiences as a tool to support the environmental regularization program in different Brazilian biomes

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The success of the environmental regularization program in Brazil depends on the scientific knowledge in plantings of native species used for restoration techniques, public policies to stimulate environmental regulations, economic valuation of environmental conservation and access to information by farms. To meet these demands, the Brazilian Agricultural Research Corporation (EMBRAPA) and the Ministry of the Environment (Secretary of Extrativism and Sustainable Rural Development (SEDR) and the Brazilian Forest Service (SFB)) gathered together technical information such as suggestions of native plants, strategies for vegetation restoration, ongoing experiences, and best agricultural practices, to create an interactive information system to assist in decision-making and to guide technicians and owners of rural areas on choices of native species, best practices and appropriate strategies for vegetation recovery in the Amazon, Caatinga, Cerrado, Mata Atlântica, Pampa, and Pantanal biomes, according to environmental data on the area to be restored. The virtual platform is available at <https://www.embrapa.br/en/codigo-florestal>, as of June 5, 2017. Botanical and ecological data are available for more than 600 native species for the different Brazilian biomes. Strategies for restoration for native vegetation vary from passive actions, such as natural regeneration, to high intervention actions, such as those in agroforestry systems. Actions should start in small areas to support new decisions if something fails. These strategies can be applied in Brazil for Legal Reserve Areas (ARL) and Permanent Preservation Areas (APP) to meet the requirements of the Brazilian Federal Law of Native Vegetation Protection (12651), May 25, 2012.

S88 Integrated approaches to monitoring and evaluating the restoration of fragile landscapes in the changing world

Organizer: Shikui Dong

S88.01 - Vegetation regeneration and succession during alpine meadow degradation and restoration on Tibetan Plateau

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The judgment of ecological engineering's impact on vegetation function is a key to develop successful strategies for regional vegetation management sustainably. We evaluated the vegetation regeneration and succession to link alpine meadows degradation and restoration in order to get the information about changes in alpine meadow under the human disturbance and climate change. Then we explained the ecological-restoring engineering's effect on vegetation structure and function in three river's headwater area in Tibetan plateau in past 20 years. Our result has three main following findings for ecological function of a significant restoring engineering on Tibetan plateau. Firstly, the land degradation had changed very much of vegetation in a large extent on Tibetan plateau, because of the poor resilience of degraded land, that could not recovered by itself as soon at current status. Secondly the method of artificial grassland building is a not a cost effective restoring approach for long term's investment with specific management and nutrition, because of the vegetation regeneration's system did not re-establishing by artificial grassland for its very few local grasses species were dominated. The third is that, we should change the opinion of alpine meadow's restoration, especially for the Kobresia meadow, because of under climate change and human disturbance, climatic climax vegetation should be coming, then our perspective of vegetation management should adapt for the climate change. In conclusion, the new action of land and vegetation care should be involved into next round of ecological engineering on Tibetan plateau, not only the ecological restoration.

S88.02 - A network-based approach to assess restoration of degraded marsh wetlands on Qinghai-Tibetan Plateau, China

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Wetland restoration projects have been spread all over China in recent decades, highlighting the increasing awareness of the importance of wetlands. Post-assessments of wetland restoration projects may provide deep insights into the effectiveness, efficiency and sustainability of projects. However, existing short-term and instantaneous assessment typically focus on the physical, chemical and biological factors, neglecting the fact that structural and functional restoration of wetlands may depend on the complex food networks that are interwoven by complex functional groups in different trophic levels. To assess the restoration effect of degraded marsh wetlands on Qinghai-Tibetan Plateau, we developed a new method that incorporates traditional assessment indicators and network indicators. Results indicate the importance of system-level, network based assessment to demonstrate the key processes of wetland restoration.

S88.03 - Study on Alpine Grassland Grazing Ecosystem Based on Equilibrium of Plants and Livestock -Theory and Practice

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The sustainable livestock production is crucial for Tibetan pastoralists who rely on healthy rangelands for their livelihood benefits, however, irrational overstocking of livestock is still widespread across the Tibetan Plateau which decreased ground cover and increased soil erosion. Overgrazing has been a subject of much deliberation, and yet conclusive evidence about its occurrence has been remarkably difficult to find in this region. Past few years, we conducted several experimental (including alpine steppe-sheep grazing trial, Alpine cultivated grassland-yak grazing trial, Alpine meadow-yak grazing trial), trying to find the optimized management practices to balance the grassland and the livestock. Our results indicated that efficiency of the livestock production was greatly dependent on the stocking rates of the grazing regime. According to the optimization model developed by ourselves, most of counties and townships in the three rivers headwater region were overgrazed in the cool-season pasture, but not in the warm-season pasture. Therefore, efforts of improved management should be directly paid in the cool season pastures. Curtailing or prohibiting livestock grazing in the cold season pastures would affect household incomes in short-term. Adjustment of the proportion of seasonal grazing area to optimize the stocking rates would be an alternative strategy, which will realize 'win-win' outcomes for grasslands and households.

S88.04 - Assessing the vegetation-cover threshold needed to control sand erosion in Hulunbeier Steppe, Northeast China

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Vegetation-cover threshold needed to control sand erosion is of great significance to ensure the optimal ecological function and production function of grassland. However, little is known about the sand erosion control vegetation-cover threshold in Hulunbeier steppe, Northeast China. Central composite design (CCD), a design of response surface methodology can be used to optimize (minimize), was taken out to establish quantitative relationship model among the wind erosion amount and wind velocity, vegetation-cover and slope of different grassland types (meadow steppe, typical steppe and transition zone between steppe and sandy land). Simulation experiments were conducted in the wind tunnel of the Laboratory of Chinese Academy of Sciences. The wind velocity in the wind tunnel can be continuously adjusted, with a maximum velocity exceeding 30 m/s. The gradient of vegetation-cover and slope were arranged according to the CCD with undisturbed steppe samples. The results showed that (1) the nonlinear model among wind erosion and wind velocity, vegetation-cover and slope in the meadow steppe, typical steppe and transition zone were established respectively. The threshold of vegetation-cover to control sand erosion of the three kinds of grassland could be calculated by substituting the field measurement and meteorology data into the model. (2) The threshold of vegetation-cover of the meadow steppe and typical steppe was 33.4% and 35.6%. The wind erosion decreased with vegetation-cover increased in the transition zone. In order to ensure the optimal ecological function and production function of the sand erosion control area in Hulunbeier steppe, the threshold vegetation-cover of 33.4% and 35.6% were recommended for meadow steppe and typical steppe. At the same time, the transition zone is prohibited from grazing.

S88.05 - Effects of climate warming and nitrogen deposition on soil carbon composition in alpine grasslands of the Qinghai-Tibetan Plateau

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To understand the patterns of soil organic carbon (SOC) molecular composition in alpine grassland ecosystems and how N deposition and warming affect the molecular composition of SOC in alpine grasslands, we conducted experiments in plots in an alpine meadow (AM), Alpine-steppe (AS), and alpine cultivated grassland (CG) in the Qinghai-Tibetan Plateau (QTP). N deposition

treatments were 8, 24, 40, 56, 72 kg N ha⁻¹ year⁻¹, a warming treatment and a combined treatment of warming and N deposition (8 kg N ha⁻¹ year⁻¹). SOC in all of three grassland ecosystems was dominated by O-alkyl carbon. The alkyl/O-alkyl ratios, aromaticity and hydrophobicity index of CG were larger than AM and AS, which generally stable under different treatments. Our findings indicated that most of the soil SOC in the alpine grasslands come from fresh plant and the carbon in the cultivated grassland was more stable than other ecosystems, whereas the composition of all ecosystems were stable under environmental changes. Thus, our study can reveal that the development of cultivated grassland may be contribute to the recovery of grasslands on the Qinghai-Tibetan Plateau.

S88.06 - Regional development optimization strategy for ecological sustainability – a case study in the Southwest China

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This paper provides a large-scale regional division approach which presents a development optimization strategy for ecological sustainability. The case study region, known as key ecological security area of southwestern China, has the extremely high development potential due to the “western development” policy. How to coordinate environmental protection and regional development is paid more and more attention. Based on the superposition of 15 indicators of environment and development potentials, the environmental value and development benefit were quantified and a partition map for four different development strategy zones was presented in this region, including conserve zones (34.90%), construction zones (35.84%), conflict zones (14.05%) and low-tension zones (15.21%). Further, conflict zones were divided into 5 levels including extreme conflict (36.20%), serious conflict (28.07%), moderate conflict (12.28%), minor conflict (6.55%) and slight conflict (16.91%). After coupling with the partitioned results, there were 9.04% of nature reserve area and 3.34% of high elevation area belong to conflict zone. To support regional management, we established construction-protection-conflict system and divided the southwest seven provinces into four categories. Covariance analysis between the partitioned results and the GDP data proved that theoretical analysis of the regional division was basically reasonable and suggested the reference significance of actual social economic development.

S89 Biological tools in soil restoration

Organizer: Pilar Andrés

S89.01 - Failing gracefully: A restoration approach for the stabilization of steep slopes in the Colombian Andes

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The long and steep slopes of the geologically unstable Colombian Andes pose a significant challenge for the maintenance of road infrastructure. Problematic slopes are stabilized with costly civil engineering techniques. However, some government agencies have questioned the obsolescence and modest durability of some stabilization works and are willing to test a restoration approach. This talk summarizes the restoration process of two pilot slopes located in mountain roads of the department of Antioquia. For each treated slope, a similar control slope was monitored but left untouched. Restoration areas were defined to include all the land that collects rainwater over the slope. Thus, the areas enhanced through restoration were larger than the areas proposed by engineers for conventional stabilization. Both pilot slopes were treated with a combination of bamboo mechanical structures designed to conduct water, and high-density planting of native herbs, shrubs and trees. Members of local communities worked in the restoration process after being trained in bioengineering and planting techniques. Ground cover, canopy cover, stem density and total vegetation volume increased dramatically after 10 months in both pilot slopes as a result of restoration. Toward the end of the project one of the roads was affected by a 100mm downpour that triggered an avalanche. The control slope collapsed with a rock and mud slide, while the enhanced slope tolerated the extreme weather event with only minor damage to vegetation. The cost of slope stabilization with the restoration approach was US \$10-24 m⁻², compared with \$33-42 m⁻² of the engineering alternative.

S89.02 - New Collembola-specific primers and their applicability in environmental monitoring using DNA metabarcoding

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The success of native reforestation efforts is often measured using structural indicators, such as canopy cover. However, it has been argued that these metrics may not provide an accurate index of the actual services provided by reforestation and there is demand to describe success in terms functional metrics. In the initial years of reforestation, the latter will be most correlated to soil physiochemical and biological parameters. We designed a sampling and metagenetic protocol to assess if Collembola species could be used as proxies for functional parameters, as these taxa are intricately tied to soil humidity, litter quality and other factors. We sampled in two ecoregions of Brazil's Atlantic Forest using pitfall traps from either forests (high quality area) or initial reforestation areas composed principally of grass cover (low quality). The PCR primers used amplified the Collembola 28S ribosomal operon (from a DNA pool consisting of the complete pitfall contents) to the exclusion of all other taxa collected. General linear models showed that Alpha diversity was best explained by habitat quality and that forests contained higher diversity. Moreover, community composition differed significantly among samples from restoration and forest areas based on Beta diversity. We identified a species, assigned to the genus *Lepidocyrtus*, that was significantly associated with low habitat quality and another (of uncertain taxonomic placement) that was marginally associated with forests. The protocol described can be the foundation for monitoring reforestation success through comparisons of Collembolan diversity between newly planted areas and local forest controls.

S89.03 - Edaphic macrofauna in areas with nucleation as an ecological restoration strategy in the eastern Andes of Colombia

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The high Andean forest is one of the most biodiverse ecosystems in the world but in turn, one of the most threatened. In Colombia, it is estimated that only 5% of this type of forest is conserved. Currently, some *Pinus patula* plantation areas, which had previously been high Andean forests, are being clear-cut to restore the native forest. In this research, we evaluated the edaphic macrofauna over time in 11 vegetation nuclei and in 12 control plots, after *P. patula* clearcutting. We compared the abundance of each species between passive and active restoration sites with a high Andean forest (reference ecosystem), following the Community Structure Integrity Index and the Higher Abundance Index, as well as some classic indices such as richness and beta diversity. Sampling of edaphic macrofauna was carried out by using the Tropical Soil Biology and Fertility (TSBF) method. Twelve monoliths, at a depth of 0-10 cm, were collected in the reference forest and in the control site, and 22 in the nuclei. Monitoring was carried out for 20 months in the control and for 14 months in nuclei. Results indicate that the successional process, at the end of the monitoring period, does not seem to advance towards the reference forest, which is probably a consequence of the low level of needle layer degradation, that is reported to be close to 30 months.

S89.04 - Post-restoration indicators of belowground communities structure and functionality: A 20-year journey across soil biodiversity

PILAR ANDRÉS

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Post-restoration monitoring programs for terrestrial environments are mostly based on aboveground plant and animal indicators of ecosystem structure (species diversity, assemblages) and functionality (plant production, carbon storage, nutrient availability). However, in terrestrial ecosystems, most biodiversity is located belowground and carbon stored in soils worldwide surpasses the amount of carbon stored in plant biomass and the atmosphere. Most environmental services delivered by soil are due to soil dwellers whose activity determines nutrient cycling rates and soil fertility, and greatly influences plant communities. Lately, important attempts are being made to develop biological indicators of soil quality, but there is still little evidence of predictable patterns in soil biota community composition across secondary succession. We present here the results and conclusions of twenty years of research on biological indicators based on soil microbial and invertebrate communities. We have been monitoring the evolution of severely degraded soils after restoration with plants (spontaneous succession, herbaceous cover introduction, tree plantation) or with plants combined with addition of organic matter in different forms (green compost, sewage sludge, biochar). When used independently, different members of the soil community (microbes, mites, collembola, etc...) often show contradictory successional patterns, and the same applies for epigeous arthropods (beetles, ants). In pursuit of synthetic indicators reporting on the structural and functional evolution of the restored soils, we are currently applying a trophic web approach that is yielding promising results in order to evaluate soil functionality and resilience after restoration.

S89.05 - Assessment of soil fauna footprints in a rehabilitated coal mine through micromorphology and near infrared spectroscopy (NIRS) analyses

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Soil micromorphology analysis and Near Infrared Reflectance Spectroscopy (NIRS) are useful techniques to assess the participation of soil macrofauna in the formation of aggregates and soil structure, which is important in pedogenetic processes of technosols. The aims of this study were to evaluate the sensitivity of the NIRS technique to recognize biologically produced soil macro-aggregates and to analyze macrofauna contribution to several pedogenetic processes through micromorphological observations of soil thin sections in rehabilitated areas at "Cerrejon" coal mine (Colombia). Soil macroaggregates were subdivided

in three categories: biogenic, physical and non-aggregated soil. In total, 32 samples were used for NIRS analysis, while ten thin sections were used for micromorphological analyses. All samples were taken from areas with different age of rehabilitation (from 1 to 20 years) and in natural forests. The results from NIRS spectra showed clearly separation among the aggregate categories. Likewise, an increase in biogenic aggregates was observed in the intermediate and advanced stages of rehabilitation. The micromorphological analysis evidenced changes from unaccommodated peds, planar and simple voids, frequent loose infilling and translocation of soil particles, observed in the initial stages to the formation of consolidated aggregates, and a reorganized structure in terms of porosity (voids complex) and aggregation (granular complex) in the 20-y site. Soil biological activity, mainly macrofauna footprints were recognized with both techniques and scales (micro- and macro-morphology). These results allowed us to show how the rehabilitation program performed in “Cerrejón” mine are promoting the establishment of soil macrofauna population that favor bioturbation.

S90 Restoration Economy II

Organizer: Rubens Benini & Bernardo Strassburg

S90.01 - Fundamental Aspects of The Economics of Restoration

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The Economics of Restoration is a relatively recent field of research if compared to, for instance, the economics aspects of conservation. Indeed, most of the early work on the economics of restoration was based on established approaches in the field of conservation. Although many important insights have been provided by this, it also became increasingly clear that restoration had key differences from conservation that would strongly impact and bias research results and policy recommendations. In this talk we will explore some fundamental aspects of the economics of restoration and discuss the impact that variables such as time, workforce requirements, level of intervention in the status quo, among others, have for socioeconomic analyses of restoration and for policy recommendations derived from it. We will also discuss how the distribution of costs and benefits among stakeholders across time and space can impact these analyses and recommendations. Finally, we will explore how classic market failures impact the restoration sector and how these can be addressed in order to help restoration initiatives achieve the most desirable outcomes for societies.

S90.02 - Investing in nature conservation and restoration pays

RUDOLF DE GROOT

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Money spent on nature conservation and restoration is still seen as a cost. However, if we are honest about all the benefits, money spent on ecosystem restoration is an investment that generates high economic returns, in addition to ecological and socio-cultural benefits.

Ecosystems provide a range of services, many of which are of fundamental importance to our health, livelihood, economy and general well-being. Yet, despite international commitments, global biodiversity continues to decline at unprecedented rates. Ecosystem degradation and the loss of biodiversity undermine ecosystem functioning and resilience and thus threaten the ability of ecosystems to continue to supply the flow of ecosystem services.

In addition to the environmental and social costs, ecosystem degradation has huge economic costs: a recent publication in *Global Environmental Change* (Costanza et al, 2014) estimated the global damage, mitigation and repair costs at between 4 – 20 trillion US\$/year, a large portion of GDP in many countries.

Based on a number of case studies this presentation will show that investing in ecosystem restoration provides high economic returns which is increasingly acknowledged leading to many initiatives to better capture the 'true value' of nature and change our conventional, unsustainable economic system.

S90.03 – Large Scale Multi-Species Reforestation

BRUNO MARIANI

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Large-scale reforestation has been recognized by the Paris Agreement as an important tool for keeping the global average temperature below 2°C. Key among Brazil's contribution to this cause are the restoration and reforestation of 12 million hectares; an ambitious goal that will require the combination of several strategies including the enforcement of the Forest Code and Native Vegetation Protection Act, as well as the establishment of a large scale nationwide reforestation effort. Symbiosis has developed a scientific innovative forestry system focused on high value commercial hard wood species, native to the Brazilian Atlantic Rain Forest. Inspired by natural succession of the tropical forests, our model combines economic return and the restoration of the ecosystem's vitality, all on the same business model. Recent international research has shown that multi-species forests are more resilient and resistant to disturbances such as insects, draught and climate change. Such forests also increase water retention and restore a healthy soil. After seven years and 53 species tested, a group of 22 tree species were selected for a combination of ecological function, commercial value, shape, growth speed and color. Our commercial plantation occupies 60 % of the total area and it is managed without clear cutting. The balance, including the Permanent Protection Area and Legal Reserve, is enriched with 160 different native species and is conducted with the objective of conservation and the protection of the fauna. Symbiosis system is replicable in other areas of the tropics and viable from a large-scale production model to a small family property.

S90.04 – An economic evaluation of the livelihood benefits of a rehabilitated wetland, Mpumalanga Province, South Africa

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Investment in wetland rehabilitation has been significant, yet the associated monitoring and evaluation has lagged behind. Towards addressing this gap, the rehabilitation of a wetland in Mpumalanga Province, South Africa was evaluated. A pre-rehabilitation survey revealed that, while severe erosion of the wetland had occurred, portions of the wetland remained intact and were used by the local community to generate livelihood benefits. However, based on the past rate of advancement, it was projected that erosion would likely progress, resulting in the loss of livelihood benefits. Structural rehabilitation was implemented to halt erosion. It was hypothesized that rehabilitation would secure the integrity of the remaining wetland thereby safeguarding livelihood benefits. An evaluation, six years later, aimed to test the hypothesis. This paper describes the economic component of the evaluation. The contribution of the rehabilitated wetland to local livelihoods was assessed and compared to the likely contribution under a scenario of continued erosion (without rehabilitation). A system contextualisation, biophysical assessments, focus-groups, interviews, in-field surveys and related research findings informed the evaluation. To date, the rehabilitation has successfully halted further erosion and supported the continued use of the wetland by the community, especially vulnerable groups, to generate livelihood benefits. Positive NPVs suggest the rehabilitation was financially efficient, when considered at a three percent discount rate (25 years) and a six percent discount rate (50 years). Additional benefits (e.g. option value) and beneficiaries are yet to be investigated suggesting that present estimates represent a lower bound of the added value of the rehabilitation.

S90.05 - Trade-offs of ecological restoration project implemented by local government: A case study in urban mined area, Xuzhou, China

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This case provides a way for local government to tradeoff the ecological restoration decisions. The case is located in Xuzhou Economic Development Zone, Jiangsu Province in eastern China. The long-term quarrying had caused the green hill damaged, leaving behind extensive vertical slopes and a dozen pits which had serious geological hazard and environmental pollution. According to the restoration model developed in this paper, if it were restored as a city park, the total investment should be up to at least 0.24 billion Yuan RMB (about 34million US dollars). But if it were not restored, it would devaluate the surrounding land value. According to the spillover effect model developed in this paper, if it were developed as a city park, its impact area would cover adjacent 13square kilometers, and the average value of land would increase by 6 percent, and the spillover effect would reach up to 1.17 billion Yuan RMB. The local government of Xuzhou Economic Development Zone ultimately made decision to its ecological restoration after long debating and tradeoffs. The park was constructed from 2008, and completed in 2015 and it was eventually transformed as the Zhushan Stone-pit Relic Park.

This ecological restoration case shows that the local government's decision-making should not focus on the benefits of the project itself, but should consider its external potential effect from a higher scale. The spillover effect of ecological restoration project could be a driving force for local government to make decisions.

S91 The role of priority effects during assembly for ecological restoration

ORGANIZER: VICKY M. TEMPERTON

S91.01 - Current overview of research on priority effects and its relevance to restoration

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Priority effects occur when organisms that first arrive at a site significantly affect the establishment, growth, or reproduction of the species arriving later, thus influencing further assembly. In order to advance understanding of community assembly, there is a need to synthesize existing literature on priority effects, explore variation in results, and identify gaps in knowledge. Toward that end, we conducted a literature review of priority effects with a specific focus on plant communities. We found that although many authors framed their work in the context of priority effects, only half of the articles actually experimentally manipulated order of arrival to assess effects on community assembly. In the experiments that tested priority effects, most were conducted in USA (67%) and Europe (20%), in grassland, and in controlled experiments. More than half of the experiments tested the effects of order of arrival between exotic and native species. We also found that the number of publications about priority effects has increased significantly since 2012. There is a need for researchers to move beyond controlled experiments at small spatial scales and to test effects at restoration-relevant scales, as well as on how order of arrival can affect the performance of species from habitats others than grasslands (e.g. savannas, forests, heathlands, bog species). In addition, it is necessary to propose a clearer concept to define what should be considered a priority effect, and what not.

S91.02 - Exploring priority effects in a central European grassland field experiment in order to inform restoration

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The role of history in community assembly is uncontested. Species that arrive first can significantly affect further assembly by creating priority effects that affect ecosystem functioning and services as well as community composition. Thus, there is a potential for using priority effects for restoration, in order to steer communities to a desired restoration outcome. European grasslands are some of the most diverse habitats globally on a small scale, but are severely threatened by both agricultural intensification and land abandonment. We tested whether priority effects of order of arrival can be used to create more productive yet still diverse grasslands that motivate both farmers and conservationists. We established a grassland field experiment in Germany combining biodiversity and assembly approaches on two different soil types. We studied the effect of order of arrival of three plant functional groups (grasses, legumes and forbs) and of sowing low / high diversity seed mixtures on species composition, aboveground and belowground biomass. Whilst sown diversity did not affect aboveground biomass, changing the order of arrival affected both above and belowground biomass and species composition. Sowing legumes first created priority effects with higher aboveground and lower belowground biomass (lower root length). Priority effects created by changing order of arrival were more consistent below than aboveground, indicating an asynchrony between processes below and aboveground which may have repercussions on ecosystem functioning as well as service provision. Further studies will test the role of year of initiation on priority effects and their relevance for restoration.

S91.03 - Context-dependence of priority effects in the restoration of California grasslands

TRUMAN P. YOUNG; KATHARINE L. STUBLE; KURT J. VAUGHN

We examined multiple contingences in a controlled set of restoration experiments in grasslands/rangelands in north-central California Restoration, including priority effects, year effects, and site effects. Practitioners have long noted that restoration outcomes vary strongly across years and across similar sites, but field ecologists have been slow to examine such contingencies. First, we demonstrated that we could give desirable plants a better chance of establishing in restoration projects by giving them a 'head start' of either two weeks or one year (called priority effects). This could provide a helpful tool in settings where a) noxious weeds often choke out desirable plant species, and b) some species in a restoration mix are initially very competitive, and exclude other desirable plants in the mix. Second, we demonstrated that even subtle differences between sites and between planting years can profoundly shift the outcomes of restoration plantings in general, and of the importance of priority effects in those plantings. These results suggest that we need to do a better job at testing the generality of our research, since most ecological field experiments are currently initiated in a single year at a single site. Third, using watering experiments embedded in our overall design and statistical analyses across our many experimental trials, we were able to show that a substantial amount of the variation in our restoration plantings from year to year was due to the timing and amount of rainfall. Fourth, we were able to demonstrate that although these priority relationships with rainfall may hold over a normal range of years, they break down when rainfall patterns shift in the directions projected under climate change. These results contribute to the growing evidence that managed and natural biological systems are far more richly contingent than previously recognized.

S91.04 - Are priority effects driving the assembly of tropical forests undergoing restoration?

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Priority effects have been slowly understood in the context of ecological restoration, especially for grasslands and herbaceous plants. The role of the first to arrive, however, have rarely been explored when it is about tree species or forest ecosystems. Considering that trees are long-lived organisms, priority effects, if occurring, should give the species introduced in a degraded area the long-lasting power of driving the community assembly and the future composition of the restored forest. We assessed the set of planted species and the young trees spontaneously regenerating (that represent the future composition of these forests) under pure and mixed stands of tree species planted to restore forest ecosystems in Brazil. We found as a rule that the identity of the trees planted does not determine the future composition of these forests. The abundance of the species spontaneously regenerating, however, is influenced by functional traits of the species planted, related to the resulting light availability and thickness of the litter layer. The future composition of restored forests will be mostly determined by seed dispersers and seed sources in the regional species pool (forest remnants and isolated trees), with animal-dispersed and shade tolerant species dominating. With rare exceptions, planted species (the first to arrive), even exotics, tend to lose space for immigrant natives (the latter to arrive) over time. The community assembly in these forests undergoing restoration is, therefore, driven by ecological filters constraining seed dispersal and plant establishment, a pattern more related to the succession than to priority effects.

S91.05 - Can priority effects prevent invasion in Cerrado (Brazilian Savanna) restoration?

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In Brazil a large portion of Cerrado, the Brazilian savanna, has been converted into exotic grass pastures. Exotic grasses are difficult to eliminate, due to vegetative propagation, abundant long-lived seed bank and propagule pressure from surroundings. To increase restoration success in a savanna in Central Brazil, we tested the hypothesis that once native species are established, they would prevent exotic grasses re-colonization, but if exotic grasses were present, they would outcompete native species; the so-called priority effect hypothesis. For two years, we observed the dynamics of 1-3 years-old savanna communities established through direct seeding of native species on a previous exotic grass pasture. We established 120 plots (1m²) in a gradient of vegetation cover, ranging from only native to only exotic species. We compared the variation in groundcover between plots first

dominated by natives, exotics or with mixed initial dominance. For both native and exotics, their relative cover were reduced in plots first dominated by themselves, and did not varied in plots with mixed initial dominance. These results indicate equilibrium between natives and exotics, and that none of them were favored by priority effects. Both native and exotic grasses and forbs were able to disperse and colonize plots where they were not present before. However, total vegetation groundcover is still increasing, indicating that colonization is high and competition is still low. If these results remain in the following years, it will indicate that priority effects do not prevent spread by exotics, neither by natives.

S91.06 - Can knowledge of priority effects improve outcomes of ecological restoration?

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Successful ecological restoration requires removing degradation and returning the target site to the condition that it would have been in if it had not been destroyed. Restoration targets and reference models generally are developed without considering of the equilibrium dynamics of the target system. Ecosystems vary, however, in the extent to which successional development involves deterministic changes toward a single equilibrium state. Setting restoration targets for systems with single equilibrium endpoints requires different considerations than does developing targets for systems that exhibit multiple equilibrium states (i.e. develop along two or more distinct pathways). In these systems, with complex equilibrium dynamics, history (i.e. priority effects) and stochastic factors may play a larger role in successional development than do deterministic factors. Knowledge of the equilibrium dynamics, including the potential importance of priority effects on ecosystem assembly, can help restoration practitioners with both developing appropriate restoration targets and with assessing treatment efficacy and effects. For instance, a broader set of restoration targets may need to be employed in ecosystems with strong priority effects than in those in which history does not influence successional outcomes. In addition, understanding priority effects can aid managers in determining the order of species introductions to achieve different ecosystems conditions across restoration project and program sites and can also help with more effectively interpreting treatment success. For practitioners to incorporate equilibrium dynamics and priority effects theory into practice, however, there is a need for much greater understanding of the factors that are predictive of single versus multiple equilibrium endpoints.

092 Public policies for ecological restoration in Brazil

092.01 - Complying with the Brazilian Forest Code: the role of municipalities in Mato Grosso

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The implementation of the 2012 Brazilian Forest Code is fundamental to fulfill the commitments presented in the Conference of the Parties (COP 21) in 2015. Brazil committed to restore millions of hectares of degraded land, which is an ambitious initiative and a complex challenge in the long term. In this regard, municipalities have a key role in translating national policies into local initiatives supporting environmental restoration and conservation. While light has been shed on “model” municipalities in this regard, there is little knowledge on the situation in others. A general understanding of the different roles municipalities can play in supporting restoration is crucial in achieving the national environmental engagement. Focusing on the Amazon part of Mato Grosso state, desktop research as well as field interviews and surveys allowed us to build a large inventory of the different public initiatives supporting restoration in private lands. Crossing the collected information revealed that: i) support to landowners is often minimal, restricted to land registration and tree seedlings provision; (ii) successful projects are enabled through various forms of institutional arrangements; (iii) the main limitations in implementing initiatives are a lack of human, material, political and financial capacities within municipalities. These results underline the importance to better understand the factors that enable or weaken implementation of the Forest Code at the local level to better target federal support towards municipalities.

092.02 - Gaps and bridges between science and practice: Ecological restoration in Rio de Janeiro, Brazil

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Ecological restoration is a pathway for achieving biodiversity conservation, enhancing the provision of ecosystem services, mitigating and adapting to climate change, while promoting socioeconomic development. To successfully achieve regional and global restoration targets, it is important to understand how different stakeholders engage with restoration processes and how efforts at nested scales integrate. We conducted a literature review of scientific studies, policy papers and publications from governmental agencies, NGOs and private companies that operate in Rio de Janeiro state. We also interviewed key actors at those institutions to identify their motivations for restoration, sources of funding, strategies adopted and indicators used for monitoring. Restoration science has advanced significantly, exploring different strategies from conducting natural regeneration to refaunation. However, our results show that a considerable distance between theory and practice persists: NGOs and private companies have adopted the strategy of dense tree planting in virtually all projects. Most of the scientific studies were performed inside protected areas and focused on ecological indicators. Meanwhile, there is growing pressure for restoration in private lands to comply with the law, and reducing costs to make it feasible is urgent. Public policy has historically focused on restoration as environmental compensation, which became the main driver of restoration in RJ. Short management period was identified as a limiting factor for restoration projects by all stakeholders. Our results highlight the need for diversified restoration strategies, greater integration between different segments of society and investments in long-term projects that consider socioeconomic factors, the main challenges to be overcome.

092.03 - Towards Forest Restoration in Maranhão State, Eastern Amazonia

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Illegal deforestation of the Amazon forest in Maranhão state persists in a violent process that provokes visible social, economic and environmental harm. To promote the conservation and restoration of this region, the Maranhão Amazon Forest Conservation Network was created in 2014. The network consolidated a database of environmental and social data, and mapped deforestation, forest fires and secondary growth. Currently, only 25% of the original forest cover (25 thousand km²) remains, of which 57% is in protected areas (Indigenous lands and Conservation Units) under high pressure by illegal logging associated with severe human rights violations. More than 30 indigenous people were murdered in the last ten years defending their territories. Fire is still extensively used in agriculture; only in 2015 30,137 heat foci were detected. The region faces water shortages and is the most vulnerable to climatic changes in Brazil. Conversely, secondary vegetation covers 20 thousand km² (27% of deforested area) and is completely unprotected. Contrary to Brazil's international commitments to combat deforestation and restore forests, the Maranhão state government has sought legal mechanisms to diminish forest cover in public and private areas. The Network seeks bases for a restoration policy that prioritize the protection of secondary forests, no-fire agricultural practices and agroforestry in the state. In the poorest region of the country with an economy essentially based on predation of natural resources, restoration costs must not only be minimized but also bring direct social and economic benefits.

092.04 - Achieving Zero Net Deforestation through forest restoration in Pará State, Brazilian Amazon

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Pará State lost 21% of its rainforest and shows the higher deforestation rates in the Brazilian Amazon (3,025 km² in 2016). In 2012, Pará State Government announced the commitment to achieve Zero Net Deforestation (ZND) by 2020. To reach this goal, three steps are paramount: drop deforestation rate, improve efficiency in cattle ranching production and scale-up forest restoration. Despite the importance of forest restoration for the ZND success, mechanisms for restoration governance are lacking. We evaluated the challenges and opportunities for the implementation of public policies to scale-up forest restoration in Pará through literature review and analysis of secondary data. Our results indicate that the main challenges to promote forest restoration in Pará are: the high implementation costs (2,5 - 3 billion dollars to restore approximately 30,000 km², 13% of the total deforested area of Pará State), the lack of financing schemes, delay of Rural Environmental Registry (CAR, in portuguese) validation, deficient law enforcement and lack of land tenure regulation. As for the opportunities, economic incentives are mandatory to breakthrough restoration initiatives in large scale, such as payment for ecosystem services and funding to establish credit for agroforestry, silviculture and the entire restoration chain. In this context, achieving the ZND requires a short term engagement of civil society, private sector, federal and state governments in order to implement policies to overcome those challenges and promote a forest restoration economy in Pará.

092.05 - A public policy to enable large-scale forest restoration in Brazil

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It is estimated that 12.5 million hectares of forests need to be restored in Brazil within the next 20 years to comply with the Forestry Law (Law n° 12,651/2012). However, in order to achieve this ambitious restoration goal, it will be necessary to overcome the various obstacles that currently hamper large-scale forest restoration in the country. Among them, is the lack of native seeds and seedlings with adequate quality, diversity, and quantity to be planted in areas of low natural regeneration capacity. This indicates the need to promote the supply of these inputs through specific policies. Aiming towards strategies to minimize this

problem, we reviewed the literature on the subject and propose a public policy to support the production and commercialization of these seeds. The proposal is to use public purchases to promote the forest restoration chain through the acquisition of these inputs directly from family farmers. It is suggested to create a public program to simplify the legal requirements for these purchases and stimulate small-scale, decentralized production. The seeds purchased would be used to restore areas under the responsibility of public authority and they would also be donated to farmers who needed to restore areas on their properties. Purchases will be scaled by a technical restoration project and the seeds would be bought from nearby areas with vegetation similar to the places where they would be used. Adoption of this policy may also be appropriate for other countries that need to encourage large-scale forest restoration.

093 Restoration of drylands and mediterranean ecosystems

093.01 - Novel methods for restoring arid lands

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Dryland Restoration has been continuously facing failing threats due to drought that impair plant survival. Restoration programs in Brazilian semiarid forests (Caatinga) frequently face 70% plant mortality. Intensive irrigation improve plant survival, however, in dry systems water is a rare resource that should be protected for human use. We developed a novel restoration technique that avoid continuous irrigation and improve plant survival even when planting is performed during dry conditions. Experiments were conducted in a degraded area at the National Forest of Açú, northeast Brazil. Irrigation and plant shape treatments were applied in a split-plot design with five replicated blocks. In each block, irrigation twice a week for one year and no irrigation treatments were randomly assigned. Inside each treatment, six native tree species were planted with the following shapes: 1)small root +small shoot; 2)small root + large shoot; 3)large root + small shoot; 4)large root + large shoot. Large root plants were produced in greenhouse using PVC tubes for root elongation. Measures of survival and growth were taken during three years. Plants with large roots and large shoots had significantly higher growth and survival even in no irrigation treatments. This planting technique was then applied in a large scale restoration program covering 3,3 ha of plantations, using 16 native tree species, 4800 trees. Tree survival after the first dry season (eight months from planting) achieve 80%, a unique restoration success result that was never before registered for such ecosystem.

093.02 - Germination behaviour and hydrothermal thresholds of Australian arid plants: Implications for the restoration of water-limited ecosystems.

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Ecological restoration following severe disturbance presents obstacles, though restoration in water-limited ecosystems is further complicated by variable climate and slow growth rates of keystone species. Addressing the challenges of arid ecosystem restoration is increasingly important at a global scale due to a large number of mining operations being located within arid and semi-arid regions. Following mineral sand mining in arid south-eastern Australia, important native shrubs have regenerated, however tree species have proven very difficult to re-establish. Through replicated laboratory and field experiments, this study reveals thresholds for seed germination, in terms of rainfall and temperature, and explains that changes in the spatial and temporal availability in soil moisture may inhibit plant establishment under current restoration efforts. To reveal the germination ranges of native species, seeds were germinated under eight constant temperatures and nine different water potentials. Species had impeded seed germination under limited water availability, with germination inhibition at osmotic potentials lower than only -0.75 MPa. While all species demonstrated fast germination rates, tree species required wetter conditions over longer periods of time for maximum germination to occur. This study examines ten years of meteorological data, to model when soil water conditions are most likely to coincide with optimum timing of seeding for species. Quantifying the germination behaviour of seeds across an array of environmental conditions, provides an opportunity to increase the overall restoration success through the physical restoration of soils, where structure translates to hydrothermal conditions favourable for seed germination.

093.03 - Soil depth constrains restoration options in drought-prone habitats

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In arid or seasonally dry environments, perennial evergreen vegetation depends heavily on stored soil water. The ability of soils to store water is often constrained in land that is degraded or land that is newly created after major disturbances such as mining. Restoration of such lands often deals with the challenge of limited soil depths, simply due to a lack of soil, or due to the presence of hard impenetrable subsoil or rock. In this presentation we examine the likely consequences of constraints to soil depth on the growth and physiology of restored vegetation. We will use results from a 2-year case study at a mine site in semi-arid Australia, where soil depth was manipulated experimentally. Root depth distribution of five study species was strongly affected by soil depth, and plant water relations varied accordingly. Plants in shallow soils experience earlier and more severe drought stress, which reduces rates of transpiration and growth, which in turn reduce the water requirement and rate of soil water depletion of the vegetation. Shallow soils therefore cannot sustain the same vegetation as deeper soils, but if species composition and vegetation structure targets are realistic, and land stability is guaranteed, successful ecological restoration may be possible.

093.04 - Restoration of coastal dune ecosystems in central Israel following removal of a 60-year old Eucalyptus grove

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Three quarters of the Mediterranean Basin's dune habitats have been disturbed or destroyed in the past 30 years; Israel's coastal plain is no different. Only approximately 17% of Israeli coastal dunes are still reasonably intact, and less than 12% are nationally protected areas. Over the first decades after establishment of the State of Israel, great efforts were made to stabilize coastal dunes, using exclusively non-native plant species. Today these species, especially *Eucalyptus camaldulensis*, cover broad areas, effectively stabilizing the sand and profoundly modifying the native ecosystems and landscapes, both above- and below-ground. The current study focuses on the first three years of a restoration process following removal of 20 ha of *E. camaldulensis* forest, planted in the 1950s on coastal sand dunes at the Alexander River National Park. We used two different levels of intensity of restoration methods, compared with two types of untreated controls – *Eucalyptus* grove and natural sand dune ecosystem. We included 10 replicates for each treatment, each 1000 m². Variables measured were soil properties and plant, arthropod and reptile diversity and abundance. A year after clear-cutting, the data obtained show dramatic changes in soil properties (Moisture content, % organic matter, pH, and rate of decomposition). We also found changes in species diversity and community assembly in all taxa studied, as species associated with sandy habitats reoccupy the clear-cut plots. Our preliminary results indicate positive trends in the initial phases of restoration of coastal sand dunes.

093.05 - The role of plant spatial pattern and functional diversity in dryland restoration

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Feedbacks between the spatial pattern of plant patches, resource redistribution, and plant growth, control the dynamics of dryland vegetation. Understanding these structure-function relationships is of critical importance for the successful design and implementation of dryland restoration. Using dryland mesocosms, with plant communities of particular functional composition and spatial patterns installed ad hoc on bare soil, we investigated the feedbacks and interactions involved in dryland dynamics, and how these feedbacks were modulated by plant functional traits and diversity. On a series of 24 plots, we constructed different plant communities that varied in patch density, and size distribution, and in species composition. We monitored resource redistribution and plant growth. Our experiments showed that the connectivity of bare-soil is the most relevant pattern attribute for explaining both global resource losses from dryland slopes, and local resource gains at the patch scale. The response of dryland vegetation to this resource redistribution depends on the functional types and the size of the plant patches, which modulate the strength and sign of the eco-hydrological feedbacks involved. Overall, the restoration potential of dryland ecosystems appears to be largely controlled by the combined effect of their spatial and biotic structures, which in turn depend on the interplay between pattern-dependent resource redistribution and trait-dependent plant responses.

S94 Technology Development for Valuing Ecosystem Services and Natural Capital in Restoration Projects

Organizer: Laury Cullen

S94.01 - Technology development for valuing ecosystem services and natural capital in restoration projects

LAURY CULLEN JUNIOR; CLINTON JENKINS; ALEXANDRE UEZU; FERNANDO LIMA; LUIZ CARLOS ESTRAVIZ RODRIGUEZ

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I will discuss new technologies and approaches to evaluate the natural capital of the largest restored forest corridor in the Brazilian Atlantic Forest. Over a period of 15 years, a 12-km forest corridor has been restored between Morro do Diabo State Park and the Black Lion Tamarin Ecological Station in western São Paulo state. This corridor is now being evaluated to measure its benefits for biodiversity, carbon sequestration, and soil and water quality. Using the technologies of Lidar for estimating biomass, camera traps and soundscape analysis for biodiversity, and automated sensors for water quality modelling, the research team is developing a comprehensive methodology to estimate the natural capital of forests. The goal is a toolkit that can be applied in multiple areas and contexts to quantify the conservation benefits of restoration. Our final goal is to develop a toolkit that can be applied in multiple areas and contexts to quantify ecosystems services and conservation benefits of restoration projects.

S94.02 - Airborne laser scanning as a tool to monitor above ground biomass in restored corridors connecting protected area

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As a result of the commitments signed during the 2016 UNFCCC convention in Paris, Brazil has pledged to mitigate the effects of greenhouse gas emissions by targeting in 2025 a 37% reduction below 2005 levels. A significant part of the mitigation is expected to derive from restoration and reforestation activities which have been targeted at the level of 12 million hectares by 2030. Numerous forest restoration schemes, using different funding strategies, may significantly contribute to such target. Hydroelectric power plants, for instance, in the Brazilian State of Sao Paulo have used earmarked funds to promote the restoration of riparian forest corridors on the banks of their large water reservoirs. Airborne laser scanning (ALS) techniques have been used to monitor the growth of such forests in terms of above ground biomass. This work reports on the application of such technologies to monitor the restoration of riparian corridors that connect two important conservation units in the Western part of the State of Sao Paulo. Some promising ALS metrics are used to generate accurate and affordable biomass estimates. Carbon effectively captured has been mapped on these restored riparian corridors using wall-to-wall airborne laser scanning (ALS) assessments further calibrated by field sample plots. Our work with ALS shows that active laser sensors can become an important tool to monitor the goals set by Brazil towards the Paris agreement.

S94.03 - Corridors for whom: technological solutions for biodiversity monitoring in reforestation initiatives

CLINTON N. JENKINS; ALEXANDRE UEZU; NATÁLIA MORETTI RONGETTA; SIMONE TENÓRIO; RAFAEL SOUZA; FERNANDO LIMA

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Corridors are an established and widely applied method to connect habitat fragments. Theory and empirical evidence well support them. The largest implemented corridor in the Brazilian Atlantic Forest is one of 12-km between Morro do Diabo State Park and the Black Lion Tamarin Ecological Station in western São Paulo state. Understanding what species use the corridor, and how they may affect forest regeneration, is essential to long term corridor success. To evaluate the functionality of this corridor, we deployed audiorecorders to record animal calls, principally birds and amphibians. Using the Arbimon analysis system, species

calls were characterized and more than 40,000 one-minute recordings searched. For frugivorous birds, which are important seed dispersers, we confirmed that distance from source areas (the protected areas), and the local forest structure, explain the presence or absence of select species. Knowing which seed dispersers are present, and why, will aid in the development of more effective forest restoration strategies. Importantly, strategies that lead to a more diverse and abundant community of seed dispersers should result in better and faster forest development. More broadly, our analyses of general soundscapes at survey points show distinct patterns related to corridor location and forest structure. Young and poorly developed restoration sites tend to have a more depauperate soundscape than more advanced restoration or reference sites. This suggests that soundscapes may be a relatively quick and easy way to estimate the recovery of biodiversity in a regenerating corridor.

S94.04 - Selfies in the Forest: Monitoring wildlife in reforestation initiatives

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The main initiative to promote connectivity in fragmented landscapes is the creation of ecological corridors. The largest implemented corridor in the Brazilian Atlantic Forest is one of 12-km between Morro do Diabo State Park and the Black Lion Tamarin Ecological Station in western São Paulo state. To evaluate the functionality of this corridor to mammals, and how this group may affect forest regeneration we conducted a sampling with self-triggered cameras or camera-traps. Knowing which species are colonizing and occupying the corridor as well as their ecological role in the system is crucial to develop effective forest restoration strategies. We organize more than 6,000 ten-seconds video records of mammalian species in Camera Base, a relational database designed to camera-trap sampling. Our findings so far suggest that predators and mesopredators such as pumas, ocelots and crab-eating-foxes are the species with high occurrence frequency alongside the corridor. Seed dispersers and seed predators such as agoutis are influenced by the distance of source areas (protected areas and other forest patches close to the corridor). The distribution pattern of these particular functional groups of species, combined with data from frugivorous birds (seed dispersers) collected using audiorecorders, suggests that: 1) these corridors are promoting connectivity for local biodiversity 2) natural patches nearby are crucial to maintain populations of species that will ultimately guarantee the maintenance of an ecological corridor in the long term.

S94.05 - New approaches to monitoring the effects of riparian reforestation on water quality

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The impact of riparian reforestation on water quality is a major challenge in the tropics. Several factors impede accurate estimates: 1) the water's physical and chemical parameters vary greatly over time and are especially influenced by rainfall and anthropogenic activity in watersheds; 2) measurements of conventional biological parameters are time- and resource-consuming; 3) and large-scale tropical restoration initiatives are rarely available for testing different approaches to water monitoring. We compared three watersheds in western São Paulo State to assess the influence of a 12-km restored riparian forest on water quality: a forested watershed (control) inside a state park, a watershed with no riparian forest, and a watershed with restored riparian forest. We used three methodologies to estimate: water flow regulation and sediment production, aquatic bacteria diversity, and multiple aspects of riparian quality. We tested, respectively: fluvimetric stations collecting data every 10 minutes during one year; intercept meshes for bacterial collection and subsequent DNA sequencing; and Rapid Bioassessment Protocols. We detected a gradient in water quality among the three watersheds, where the control stations yielded higher quality estimates, with better water flow regulation, less sediment production, and exclusive bacterial taxa, whilst the non-forested watershed generally presented the worst parameters. The restored watershed yielded intermediate conditions, although some measures were more similar to the unforested watershed, including regulation of water flow. These approaches appear to be sensitive to the impact of riparian forests and represent a foundation for the development of cost-effective water monitoring protocols.

S95 Restoration as tool to mitigate the effects of woody encroachment in grassland and savanna macrohabitats

Organizer: Cátia Nunes da Cunha

S95.01 - Climate change and Pantanal Wetland: restoration as tool to mitigate the effects of woody encroachment in grassland and savanna macrohabitats.

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Woody encroachment causes impoverishment and simplification of the herbaceous communities. Woody plant proliferation at current represents a threat for biodiversity and ecosystem services of grassland and savanna macrohabitats inside the Pantanal wetland and needs to be addressed by appropriate management strategies. Conservation, management and restoration depends on rangeland practices guided by scientific knowledge. Data on ecological and cultural components provide a baseline for restoration projects. We believe that Neotropical savanna wetlands with a rich herbaceous community composed of important forage species should be restored. We will bring together current knowledge on shrub encroachment, its drivers and consequences, putting the Pantanal into a global perspective and advancing in terms of possibilities of conservation, management and restoration.

S95.02 - Herbaceous plants composition and biomass shifts in macrohabitats under the influence of woody encroachment in Pantanal wetland

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Macrohabitats covered by herbaceous plants communities (i.e. grasslands and savannas) occurs in high proportion in the Pantanal wetland and are valuable as biomass source for cattle production and by the expressive contribution to diversity. Actually, some of these herbaceous macrohabitats has been gradually converted to woody plant stands with context-specific implications that should be clarified to subsidy policies for conservation and restoration in the Pantanal. Plants are essential components of ecosystems by its distinct role in the energy flow as producers and by providing habitats, being a good indicator of ecological processes and vegetation character. So, we determined plant species composition and diversity of herbaceous and woody plants and herbaceous aboveground biomass at 46 herbaceous macrohabitats sites using plot techniques in the north of Pantanal, Brazil. We classify these herbaceous macrohabitats by its species composition; compare the species shared; and the mean diversity, woody density, herbaceous cover and aboveground biomass. We observed higher aboveground biomass in macrohabitats characterized by lesser flooding duration and savannic flora (C4 dominants) than in macrohabitats with longer flooding duration and hydrophytic grassland (C3 dominants) flora. The floristic patterns of C3 herbaceous macrohabitat are associated with sandy soils and grasses *Reimarochloa BRAZILiensis* and *Setaria parviflora*. The floristic in C4 herbaceous macrohabitats are associated with sandy and clay soils and grasses as *Andropogon bicornis*, *Paspalum* spp., *Axonopus* spp. Most of herbaceous plants are annual and colonize the entire gradient from permanently dry to permanently wet conditions.

S95.03 - The role of a government agency to plan ecological restoration within scientific principles

LIGIA NARA VENDRAMIN

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The “Mato Grosso State Environmental Agency” (SEMA-MT) acts to answer to the “National Policy for Vegetation Restoration” and intend to restore protected areas in Mato Grosso state. However, the restoration of native grassland under woody encroachment in the Pantanal wetland has not been included in the discussion. To elaborate new models for ecological restoration concomitant with CDB and Aichi targets principles, collaboration efforts integrating scientific understanding has been discussed to be implemented in the Pantanal and in other wetland ecosystems in the Mato Grosso state. At this moment, there

is a search for a model of ecological restoration planned as a consortium between academy, government and private initiative dealing with historical human conflicts and ecosystem needs. Which institutional arrangements facilitates the transference of scientific understanding to the public education, legislators and other environmental government agencies, as explicated by adaptive management principles? Thus, is highly important the active participation of the environmental agencies in ecological restoration activities, comprehending the need of ecosystem services valuation and the use of ecological indicators in economic models and public policies.

S95.04 - Shrub and tree encroachment in non-forest ecosystems: Consequences for restoration

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The grassland region of Southern Brazil, the Campos Sulinos, share one important feature with the Pantanal wetland region: they are subject to shrub encroachment and forest expansion when grazing activities are being abandoned. Under current climatic conditions, originally open ecosystems thus will rapidly change in overall structure and species composition. The consequence for restoration of open habitats is that disturbances - such as by cattle - must be considered from the beginning on in restoration planning, including restoration objectives. This requires changes in thinking about the role of ecological succession in restoration. Based on experiences and case studies from Brazilian non-forest ecosystems I will here discuss conceptual bases and application problems in grassland and savanna restoration in Brazil, with a special focus on global change processes, including climate change, changes in disturbance regimes and exotic species invasion. This will also consider consequences for large-scale restoration planning, for environmental politics and inclusion of people into restoration activities. Even though awareness for grassland and savanna conservation and specific restoration needs of these systems has risen recently, the need for basic studies on ecological processes in non-forest systems and for the discussion of their consequences for restoration persists.

096 Restoration in urban and periurban environments

096.01 - Restoration of urban green spaces rewilds the environmental microbiome with associated shifts in the human microbiome

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Restoration often aims to return ecosystem services – including human health benefits. Chronic inflammatory diseases have increased remarkably with urbanisation and a growing body of evidence suggests that reduced exposure to healthy environmental microbiomes results in negative health consequences. Reversing this trend may require returning ecosystem services to the urban landscape. However, it is unclear whether restoration of biodiverse urban habitat can rewild the environmental microbiome and influence the human microbiome. We propose the Microbiome Rewilding Hypothesis: planting biodiverse habitat in urban green spaces rewilds the environmental microbiome and benefits human health as a primary prevention ecosystem service. To test this hypothesis, we sampled environments and humans in three replicates of five urban green space ecotypes in the City of Playford, Adelaide, Australia. We generated rarefied bacterial 16S rRNA amplicon data for soil, leaf-surface, air, and human skin and nasal environments for community analysis. We used analysis of composition of microbes (ANCOM) to explore which bacterial OTUs changed significantly in abundance in human microbiomes. We demonstrate that revegetation returns the environmental microbiome to closely resemble that of remnant vegetation. We also show that human microbiomes change with time spent in urban green spaces. Additionally, several important human commensal and pathogenic bacteria were found to significantly differ in human microbiomes after green space exposure (ANCOM FDR-adjusted $P < 0.05$). Our study provides early evidence to suggest that restoration of urban green spaces can potentially return human health benefits as an ecosystem service, and encourages further testing of the Microbiome Rewilding Hypothesis.

096.02 - Patios for hummingbirds: First steps to restore the native plant-hummingbird interaction in Cordoba city, Argentina

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Conservation of ecological interactions among native species is one of the biggest challenges in the face of worldwide increasing urbanization. Native vegetation is typically reduced compared with exotic vegetation in urban environments. Nevertheless, some nectarivorous birds feed preferentially on urban native plants. Here, we addressed hummingbird visitation to native and exotic flowering species in urban domestic backyards (patios) in Cordoba city, Argentina. Three-hour sample periods were performed in each 'patio' from early spring to late summer (total sampling effort: 135 hours). *Chlorostilbon aureoventris* performed 92% of the visits, followed by *Sappho sparganura* (7%) and *Heliomaster furcifer* (1%). An exotic Bignoniaceae (*Campsis radicans*) was the most visited by *C. aureoventris*, and *S. sparganura* fed exclusively in *Pyrostegia venusta*, another exotic Bignoniaceae. Despite the overall higher preference for exotic Bignoniaceae, a seasonal switch in *C. aureoventris* feeding behavior was observed. In spring, when only the 6% of the flowering plants were native, half of the visits were registered on native species. In summer, however, when 40% of the flowering species were native, visits were mainly registered on exotic flowers. The profuse flowering of exotic ornamental plants in summer may have counterbalanced its relative abundance compared with native species. Given that the native Bignoniaceae *Dolichandra cynanchoides* depends strongly on hummingbirds for setting seeds, a program for the reintroduction of this species is proposed to restore the interaction between hummingbirds and native species in Cordoba city.

096.03 - Regional rather than local urban forest restoration

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World-wide, non-native and invasive plants threaten ecosystem structure and function with estimates of global damages costing hundreds of billions of dollars per year. Consequently, their removal is commonly prescribed in ecological restoration practice. While most ecological restoration projects are inherently narrow in scale and reactive in nature, taking a broader, more proactive approach is widely promoted. We used ArcGIS to explore the spatial distribution of *Pyrus calleryana* Decne. invasions in an urban matrix and to predict on a landscape-scale what areas are most susceptible to future invasion to direct ecological restoration efforts. Originally developed as rootstock for edible pears, *P. calleryana* has become a popular ornamental street tree and more recently has been identified as invasive. While much is known regarding its longstanding horticultural history throughout Asia, Europe, and the Americas, little is known regarding its patterns and mechanisms of invasion. To better understand its invasion ecology, we compared line transect survey data from urban forest stands in 18 county and 18 city parks throughout Columbus, Ohio, U.S.A. with existing street tree datasets. Our analyses suggest a positive association of *P. calleryana* invasion with forest edges and nearby planted individuals. Additional investigation, however, is needed to determine what biophysical site factors also influence this invasion pattern. With this invasive species' range growing rapidly in urban areas, understanding the influence of local governments is of great value to restoration ecology practitioners and policymakers to focus proactive measures before invasion occurs in the first place.

096.04 - Measuring urban biodiversity

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During the last decades Ecological restoration emerged in urban environment as a solution to the problems of eroding biodiversity. In European cities this issue was expressed in term of restoration and conservation of urban biodiversity becoming increasingly important and part of the political agendas of the major urban areas. The decline that biodiversity is suffering is partially attributable to the growing urbanization, which is undermining the variety of living species. How to measure this decline and the impact of public interventions aimed at reducing this erosion restoring urban ecosystems, are central questions for any government that wishes to promote a future oriented towards sustainable urban innovations. Starting from an in-depth analysis of a French urban biodiversity practices, the paper will focus on the definition of measure used to evaluate the urban biodiversity process. The aim is to provide a critical reading of the quantitative measure currently adopted and to define new possible dimensions to consider in the measurement of urban biodiversity. The general goal is to give more complexity to the standard measures adopted to grasp the aspects of a fundamental relationship for the restoring processes in urban area that is still underrepresented, namely the one between living species, humans and urban transformations.

S97 Seed-based Restoration: Innovations, Opportunities and Challenges - Using Seeds (part 2/2)

Organizer: Kingsley Dixon

S97.01 - Nursery production of wild seed resources: Managing genetics while maximizing production

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All though based in temperate North America and serving the highly urbanized greater New York City region, the methodologies employed by the Greenbelt Native Plant Center (GNPC) are widely applicable to the global restoration community. The GNPC carefully manages its production practices to conserve the wild genetic resources it draws on for its nursery production, as well as those of the restoration and land management sites that receive its nursery stock and increased seed. After an introduction to the Center's four operational programs, the talk will systematically review the various production stages from wild seed collection, through propagation and production, focusing on how the Center manages genetic resources through each stage. It will also show how we are using data management tools to facilitate this approach. The talk will also discuss the tradeoffs between its nursery practices and the need for large scale production and seed increase, while showing the genesis of its best management practices over 25 years of operation. Lastly, it will show how this approach has practical implications for its use in managing plant population health and in preparing for and navigating climate change, in part by expanding its efforts out into the larger mid-Atlantic region.

S97.02 - Using native seed in restoration of species-rich habitats – best practice examples from Germany

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The preservation of local biodiversity is of high importance all over the world. Local ecotypes are not only well adapted to their respective edaphic and climatic conditions, they also provide habitat as well as food sources for numerous animal species. For that reason, wild plants of local origin should be used in habitat restoration. However, availability of wild seed is still limited, and if seeds are available, they are quite expensive. Therefore, best practice approaches are in high demand to optimize restoration outcomes. We want to present several best practice examples, encompassing different starting points (minded land, agricultural sites) and target vegetation types (grasslands, field margins, flower strips). Restoration was accomplished by sowing site-specific seed mixtures of wild plants. Site preparation before sowing and management afterwards was adapted to site conditions. Vegetation development was documented by estimating percentage cover of species and layers once a year, ranging from two to 16 observation years. We analyzed overall and final establishment of sown species, their share of total vegetation cover, and the development of community structure. Before-after as well as with-without comparisons were made to evaluate restoration success. In general, establishment rate as well as the share of sown species on total cover are highest on raw soils, underlining the importance of low-competitive conditions in the establishment phase. For the same reason, an adequate mowing regime with biomass removal was highly important on productive sites. Concluding our results, we formulate some general rules for restoring species-rich habitats.

S97.03 - Drastic site-preparation is key to long-term reintroduction success of the highly endangered xeric grassland species *Jurinea cyanoides*

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Reintroducing endangered plant species is increasingly considered as an integral part of restoration strategies. However, little is known about the necessary extent and nature of habitat modification that secures a successful establishment of the reintroduced species. To improve the knowledge about site preparation approaches we conducted a two-site, seven-year experiment aiming at the reintroduction of the highly endangered *Jurinea cyanoides* into degraded sandy grasslands in Germany. Seeds were collected in remnant populations. We tested the treatments mowing, topsoil inversion, and inversion combined with application of turf cuttings on two sites with different nutrient status applying a Latin-Square design. We compared germination, seedling survival and reproduction success between treatments and sites using GLM methods. *Jurinea* germinated on all plots, but almost no plants survived on control and mown plots. After two years, a first *Jurinea* generation established successfully on both inversion treatments, with lower numbers on the nutrient-poorer site. In contrast, the onsite generative and vegetative reproduction was higher on the nutrient-poorer site over the third to the seventh year. In general, the addition of other xeric grassland species by turf cuttings hampered population growth, especially on the nutrient-richer site. Our experiment proved the necessity of a radical elimination of competing species and nutrient-rich topsoil to ensure successful reintroduction of *Jurinea*. Our results also indicated that site conditions more suitable for establishment of the first generation are not necessarily suitable for a successful population growth in the following years, thus underlining the importance of long-term monitoring of reintroduction experiments.

S97.04 - Using native grass seed to restore degraded grassland in northern China—examples for *Leymus chinensis* (Trin.) Tzvel

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Leymus chinensis (2n=28) is the dominant species of grasslands in Northeast China and Inner Mongolia. It is a perennial rhizome grass, commonly grows in meadow steppe, steppe and areas with barren saline soil. *Leymus chinensis* grasslands are very important to herbivores grazing in summer, and haymaking for the animals in the winter. However, *L. chinensis* grasslands are seriously degraded due to increasing grazing pressure and haying frequency. The restoration practice based on reseeding is an effective way to restore seriously degraded grassland rapidly. The seed characteristics for low seed setting rate, seed production and seed germination restricted the utilization of reseeding in the restoration based on seed. Research for improvement of *L. chinensis* grasslands has been conducted for several decades in China since 1960s. Seven new cultivars of *L. chinensis* have been released. The seed germination of new cultivars was obtained 60-80% and increased 4 to 6 times compared to the germination rate of wild *L. chinensis* seeds. Combination of soil treatments and ground cover with reseeding *L. chinensis* may improve survival rate of seedlings and yield of *L. chinensis*. Adding sand or gypsum into the saline-alkali soil can increase the survival seedling rate and density of *L. chinensis*. Covering litter on the ground of the degraded grasslands can increase the soil moisture which facilitates the seedling survival. Restoration practices of plowing and deep scarifying the compacted soil of the degraded *L. chinensis* grasslands are beneficial both for native grass growth and survival of reseeding *L. chinensis*.

S97.05 - Strategies and equipment and for large-scale, multi-species native seedlings in North American drylands

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Dryland ecosystems of western North America have experienced widespread loss of native perennial grasses, shrubs and forbs due to human disturbance, wildfire and competition from invasive weeds, especially exotic annuals. Effective restoration of these ecosystems requires strategies for maximizing benefits of limited water supply, reducing weed abundance and planting mixes of seeds differing in size, form, and physiology. Agricultural equipment adapted for rangeland forage seedlings and further modified for native seed mixes has proved useful for carrying out large-scale restoration in this region. Rangeland drills, for example, have been modified to separate large seeds requiring burial from smaller seeds that can be imprinted onto the soil surface. Annual weed competition can be reduced through the use of tillage, herbicides or fire prior to seeding, if appropriate. Wildfires present both a challenge and an opportunity for restoration in parts of the region where land management policies support post-fire seeding to protect soil and vegetation resources. Many managers have preferred to use conventional non-native forage species for post-fire seedlings, but native species are likely to become increasingly utilized if the benefits and feasibility of their use are adequately demonstrated.

S97.06 - The role of networks connecting native seed stakeholders and improving success in ecological restoration

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Connecting stakeholders and facilitating the transfer of knowledge is crucial to improve success in ecological restoration. Like the nodes of the ecological networks we aim to restore, those who work with native seeds are connected and dependent on each other for information and resources to address the challenges of seed conservation, research, production and use. The International Network for Seed-based Restoration (INSR) and the Native Seed Science, Technology and Conservation Initial Training Network (NASSTEC) are two examples of international networks dedicated to connecting people working on native seeds and facilitating the transfer of knowledge to improve results in ecosystem conservation and restoration. We present the recent activities and outcomes of these two networks. As an on-line network of 420 members in 40 countries, INSR publishes articles about restoration experiences, webinars, and a quarterly e-newsletter; promotes relevant events; posts useful materials and opportunities in seed-based restoration; and hosts a discussion forum about native seeds. As a face-to-face network, INSR organizes symposia where stakeholders can learn from each other about the techniques and approaches to restoration challenges. In Europe, where the native seed industry is starting to address seed capacity and policy, NASSTEC conducted a survey to identify the native seed stakeholders, and collect information on the degree of collaboration and networking. Obtaining information about and from the community of users that we are trying to connect and for whom we want to produce useful tools for, is a critical step to effectively direct our resources.

098 Climate change and restoration ecology

098.01 - Playing with abiotic factors and interactions between species: Options for management of endangered dry tropical forest species in Mexico to face climate change

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Dry tropical forest is one of the most endangered ecosystems worldwide and many species typical of this ecosystem could be extinct within a few decades. In Mexico, anthropic pressure has been strong and continuous. Nowadays it has become necessary to test different strategies implicated in the ability of species to respond to abiotic and biotic factors that could be limiting for their survival and persistence. Target species were *Albizia plurijuga*, *Cedrela dugesii* and *Ceiba aesculifolia*. We evaluated their performance in three different experiments: frost tolerance, altitudinal assisted migration and interactions with nurse shrubs. Frost was simulated in laboratory and tolerance was tested with fertilization of different potassium concentrations. Simulation was tested to show that seedlings could survive under current climate conditions at colder places. A test of altitudinal assisted migration was established at three altitudes (2100, 2400 and 2700 m). Plant interactions were tested with juveniles of tropical species transplanted at two distances nearby three species of native nurse shrubs. Our main results were that tolerance to frost in tropical species could be enhanced by fertilization with high concentrations of potassium that reduces electrolyte leakage. In the assisted migration test, general performance was best at medium and low altitudes but general survival was not so high probably due to climatic differences between seed sources and experimental sites. Positive plant interactions were rapidly established between native shrubs and target species evidenced by better performance of seedlings when they were nearest to a nurse shrub. Using different strategies of management could improve restoration efforts like assisted migration combined with nurse interactions and addition of nutrients might be a successful approach to test in different ecosystems.

098.02 - How successful is the restoration of alpine ponds for conserving a biodiversity threatened by warming?

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Climate warming is forecasted to be particularly pronounced in the Alps, where the biodiversity of alpine wetlands is under a high pressure. The boreo-alpine species, linked to cold temperatures, have therefore to move upwards in the mountains for seeking new habitats. A proactive management strategy is the restoration of waterbodies in altitude, for providing new habitats and also stepping stones for assisting species in their migration. But how successful is such type of restoration? Will the boreo-alpine species colonize these new wetlands? To investigate these questions, we assessed the biodiversity of 44 alpine ponds created these last 50 years through restoration measures, at high elevations (1250 to 2590 m.a.s.l) in Switzerland. Three freshwater groups were targeted: plants (passive colonizers), beetles and dragonflies (active colonizers). A total of 22 boreo-alpine species was observed. Linked to high elevation, the pond species richness was low. For boreo-alpine species, the mean richness was highest for plants (0.9 species per pond), followed by dragonflies (0.4) and beetles (0.4). Surprisingly, most ponds were rapidly colonized. After already 10 year, the species richness was near that of mature ponds. This success encourages restoration of waterbodies in the alpine landscape, especially in the upper elevation boundaries of the areas presently occupied by the boreo-alpine species. To assist the managers, we produced a “best-practice” guide for creating new ponds. For the sensitization of the general public to the impact of warming on biodiversity, we created a pilot alpine pond, for the observation of sentinel species.

098.03 - Assessment of climate change effects on pale chub (*Zacco platypus*) in Korea using a habitat suitability model

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The aquatic environment including water quality and quantity is influenced by climate change, mainly due to temperature and precipitation changes which alter the habitat suitability of aquatic organisms. In order to predict the climate change effect on freshwater fish, a habitat suitability model was developed by combining PHABSIM (physical habitat simulation system) and CLIMEX models. The proposed model, ecological habitat suitability model (EHSM), utilizes hydraulic variables (velocity and depth) and water temperature to assess the habitat suitability of pale chub (*Zacco platypus*) in Korea. The pale chub was selected as a target species due to its broad distribution in streams and rivers of Korea. Applying RCP 4.5 and 8.5 climate change scenarios, the EHS index was calculated at present (2008-2015), 2030s (2025-2035) and 2050s (2045-2055). Overall, the habitat suitability of *Z. platypus* in Korea was predicted to slightly increase in the future, compared with that of the present. However, further studies are required with various freshwater fish to preserve or restore aquatic habitats in Korea.

098.04 - Looking for native tree species tolerant to water stress based on climate change predictions in an Andean region in Ecuador

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Knowledge about Andean native tree species suitability for restoration under climate change scenarios is currently lacking. With the aim to understand native tree species seedlings responses to different water stress conditions, an experiment was setup using *Oreocallis grandiflora* and *Ocotea heterochroma* from two different seed sources (Llaviuco and Mazán forests) located at Cajas National Park in southern Ecuador. A total of 572 seedlings were raised under three water deficit treatments during four months. The treatments tested were: a) overwatering, b) 10% reduction water deficit and c) a transition from well-watered conditions to water deficit. These treatments were selected from precipitation predictions of climate change models for the southern Ecuador and compared against a well-irrigated control. The results showed that the water deficit treatments induced stress responses in *O. grandiflora* and *O. heterochroma* as reported by reduced growth, stomatal conductance and chlorophyll concentration. *O. heterochroma* was less affected by water deficit than *O. grandiflora*. When seedlings from both forests were compared against each other, no significant differences were detected in any of the variables evaluated, however, *O. heterochroma* from Llaviuco forest were apparently less sensitive to water deficit. These findings highlight challenges that need to be taken into account when selecting species for restoration under climate change scenarios

098.05 - Ecological restoration in Arctic for climate change mitigation and adaptation: First outcomes of pilot project

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Arctic ecosystems are known as fragile and having low regeneration capacity. At the same time, they play crucial role in global climate maintenance. Disturbance of carbon rich ecosystems in arctic leads to so called “carbon feedback cycle” – release of carbon stored in biomass, peat and permafrost. This enhances climate change and causes more intensive permafrost thaw followed by carbon release. Thus, restoration of arctic carbon rich ecosystems if successful should have the largest effect for climate change mitigation. The experiments on arctic ecosystems restoration were set up with support of ClimaEast program implemented by UNDP. The pilots set up in Bolshezemelskaya tundra and Pechora river delta in Nenets region of Russia. The target ecosystems had been identified as shallow peat wet tundra with active (seasonally unfrozen) layer not deeper than 1.0 m, in some cases – peatlands with peat depth more than 30 cm. The following techniques had been applied: baseline study focused on structure, natural functions, and ecosystem services evaluation; estimation of ecosystem services losses; mapping and spatial planning with differentiation of restoration activities within disturbed area; terracing, fencing to prevent wind and water

erosion, damming and filling of galleys, willow planting, transplanting of moss cover, mulching with organic material, formation of frozen lenses etc. The monitoring is focused on indicators of carbon and water balance, permafrost status, including GHG fluxes as well as characteristics of biodiversity. The assessment of effectiveness is based on the concept of ecosystem services. The preliminary evaluation demonstrates positive trends.

098.06 - Drivers of grassland-forest transitions in subtropical South America: implications for landscape restoration and management

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The conservation value of the extensive grasslands and savannas of subtropical South America has long been neglected, despite significant losses due to land conversion and anthropogenic pressures. Identifying opportunities to increase the resilience of these ecosystems is needed to assure their long term conservation. Recent studies suggest that tropical and subtropical grasslands, savannas and forests represent alternative ecosystem states that can shift depending on climate and disturbance regimes such as fire and grazing. We analyzed the role of environmental variables and changes in land use, fire regimes and agricultural and livestock management, on forest-grassland transitions over a four-decade period in the Campos region of South America. This is an extensive subtropical ecotone with high diversity of grasses and trees, with scarce native forests despite relatively high rainfall levels. We found a decrease in forests in regions with high agricultural use. Interestingly, tree cover increased in extensive grasslands where livestock densities have been reduced. Our results suggest that changes in disturbance regimes could provide opportunities to regenerate and expand forests in areas previously deforested, and that potential grassland-forest transitions should be taken into account to design management strategies towards more resilient landscapes.

S99 Public policies for native vegetation recovery on large scale

Organizer: Carlos Alberto de Mattos Scaramuzza

S99.01 - The National Policy for Native Vegetation Recovery in Brazil: the lessons-learned and further actions

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The Ministry of the Environment of Brazil, with the support of several partners, prepared a preliminary proposal for a National Plan for Native Vegetation Recovery (Planaveg) as a starting point to encourage the expansion and strengthening of public policies aimed at restoring landscapes on large scale in Brazil. The robust technical basis of the plan, obtained from the partnerships organized in a working group, were the basis of a solid and intense discussion process on the viability of the Plan, including the discussion of adequate restoration methods for the different biogeographical regions, the costs of these methods, priority areas for restoration, possible funding sources, and political articulations that would be required. This process culminated in Brazil's contribution to voluntary global forest restoration initiatives, with emphasis on Bonn Challenge and Initiative 20x20, in December 2016. The political articulation that occurred after the technical drafting of the plan culminated with the formalization of the National Policy for the Recovery of Native Vegetation (Proveg), established by Federal Decree No. 8.972 of January 23, 2017. The next challenge will be to expand the involvement of all stakeholders, including the private sector, research institutions and organized civil society, as well as sub-governmental levels (states and municipalities), in the preparation of the first Planaveg official version and in its effective implementation.

S99.03 - Economic Incentives for native vegetation recovery at different scales and their interface with public policies

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The benefits and costs of different restoration methods vary greatly over space and time. Likewise, the socioecological contexts in which these methods are implemented are also very heterogeneous in relation to their biophysical characteristics and distribution of beneficiaries. The interplay between these two aspects guarantees that the distribution of costs and benefits of individual restoration projects will be unique. When scaling these up to large scales, however, patterns emerge and it becomes possible for public policies aimed at fostering large-scale restoration to consider them. This talk will explore how economic incentives for restoration should consider multiple scales in order to capture and respond to the variation of benefits and costs across these scales. Societal benefits from restoration, from global to local scales, should ultimately be internalized into individual landowners' decision making processes if alignment between their individual decisions and societal well-being at these multiple scales is to be achieved. This is already practiced in several ways in other land-based economic sectors, such as agriculture, and lessons from these initiatives can help the restoration sector to develop and implement policies that deliver restoration of the type and scale that matches societal preferences. This understanding is also key to help to mediate potential conflicts between groups of stakeholders that can arise from restoration decisions.

S99.04 - National Standards for the Practice of Ecological Restoration in Australia: Potential to improve large scale restoration

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Public policy in Australia includes commitment to biodiversity conservation and emissions reduction at scales that require large scale native vegetation restoration. Restoration in its many forms is being undertaken by agencies, non-profit groups and communities throughout Australia to return species and functions so essential to protect the integrity of land and water systems. Although the scale and investment in restoration as an enterprise and government activity in Australia is in the billions of dollars it is only recently that Standards for restoration have been established nationally. In 2016, SER Australasia published the National Standards for Practice of Ecological Restoration in Australia after a 4-year collaboration with 12 other not-for-profit restoration organizations and input from a range of agency and industry stakeholders. The Standards encourage scaling up restoration through (i) planning that prioritises expanding and linking remnant ecosystems and (ii) implementation that optimizes the secure reinstatement of natural recovery processes. The use of an appropriate local indigenous ecosystem is a primary focus. As the Standards have emerged from the 'grassroots', it will take time for their main messages to filter through to regulatory bodies and public agencies charged with delivering policy directives for on-ground restoration. But there is growing interest from government and public agencies to use the Standards to firm up their criteria for large and small-scale publicly funded projects, and underpin legally binding closure criteria for mining and other developments.

S99.05 - From theory to practice: The application of Restoration Opportunities Assessment Methodology (ROAM) at national and subnational levels in Brazil and around the world

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In 2014, IUCN began working with the Restoration Opportunities Assessment Methodology (ROAM) in a Road Test version to test the applicability of this flexible methodological and scale-independent framework for translating restoration theory into restoration practice. Three years later, IUCN has come from 4 ongoing ROAM assessments to over 30 national and sub-national forest landscape restoration assessments across the world. Through its focus on demand-driven responses to landscape challenges, ROAM has proven to be a remarkably adaptable methodology for generating useful information that drives action and policy. It has also provided a political platform for civil discussion and planning at national, sub-national, and landscape levels. Within Brazil, several ongoing forest landscape restoration processes with different aims are using ROAM to plan and prioritize areas for restoration that will contribute economic and ecologic benefits to people. This session explores the ongoing ROAM processes in Brazil and how these sub-national assessments compliment Brazil's national strategy and its contributions to international commitments like the Bonn Challenge.

0100 Tropical forest: biodiversity and ecosystem functioning

0100.01 - Restoration plantings enhance taxonomic and functional diversity of woody plants in sugarcane-dominated landscape

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There is a lack of published information regarding the contribution of restoration plantings to taxonomic and functional landscape-scale diversity in human-modified landscapes. We evaluated woody species taxonomic and functional diversity patterns in 32 sites (18 secondary forest fragments and 14 restoration plantings) immersed within a sugarcane landscape with 10% average forest cover. We recorded woody species abundance >3.18 cm diameter in established (1000m²) and natural regeneration (250m²) strata in each site. α-diversity was assessed in three conditions: among forest fragments, among restoration plantings and among all sites, and two strata: established and regenerating plants. Traits selected for functional analyses were: seed size, dispersal syndrome, wood density and ecological strategy. For both strata, taxonomic α-diversity showed higher values than expected by chance, when fragments and restoration plantings were considered together, evidencing floristic differentiation among communities. Species replacement accounted for the majority of taxonomic α-diversity (>95%) in all conditions and for both established and regenerating plants. Functional α-diversity showed a similar pattern with higher values when restoration plantings were considered in the analysis. These findings highlight the important role of restoration plantings in the recovery of forest diversity at large scales. Our results also emphasize the urgent need to maintain the complex network of biodiversity refuges, including undisturbed and disturbed remaining forests, regenerating forests and restoration plantings to conserve plant species and functions in highly fragmented landscapes.

0100.02 - Functional traits behind the dark diversity of seasonal tropical forests undergoing restoration

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Among the species pool of a particular ecological region, not all are able to colonize the metacommunities in the landscape. This dark diversity is often neglected and unknown, in spite of its huge potential to inform biodiversity conservation and ecological restoration. We assessed all species occurring in a set of nine native forest remnants and 26 restoration sites in the region of seasonal tropical forest, southeastern Brazil. We categorized each species by dispersal syndrome, seed attributes, growth rate, shade tolerance, and rarity in the communities, aiming at identifying the functional profile of the species from the regional pool that are able or not able to colonize the habitats being restored. Surprisingly, in spite of the severe fragmentation of the forest remnants, wind and animals have been successful in moving most species across the landscape. There is, however, a dark diversity (22% of species in the regional pool) composed by tree species that are autochorous, slow growing, dispersed by terrestrial mammals or heavy seeded, which have not been able to colonize or to establish in the restoration sites, and probably are also not able to move among native forest remnants in the landscape. This evidence has strong implications for restoration practice, especially when recovering biodiversity is the goal. The species forming the dark diversity must be included in restoration projects, otherwise they will not be recovered. Priority must be given to these functional groups also in conservation policies, since they are the most threatened by land conversion and fragmentation.

0100.03 - Phylogenetic richness controlling plant growth during riparian forest restoration

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Little attention has been paid to the effects of phylogenetic diversity on the success of restoration projects. This study investigates the effects of species richness and plant phylogenetic relatedness on restoration success of a riparian forest from a region of transition between Atlantic Forest and semi-arid ecosystems in Brazil. A restoration experiment was established along a perennial stream in Monte Alegre (NE, Brazil), testing the effects of species richness and phylogenetic diversity on plant survival and growth. We used phylogenetic information on 47 plant species from the region. The resulting phylogenetic tree had a basal node with three major clades. Three species from each clade were randomly selected, resulting in nine species to settle the experiment. We defined five levels of diversity: (i) no planting, (ii) monoculture, (iii) three closely related species (same clade), (iv) three distantly related species (different clades), and (v) nine species. The experiment consists of 96 (12 x 10 m) plots placed along the two margins of the stream. Overall, 1656 individuals were planted in September 2015 (184 per species). One year later, we assessed plant mortality and height. Survival was lower but average height was higher for plants near the stream. Plots with phylogenetically distant communities had taller plants. Diversity did not influence plants survival. Our findings indicate that phylogenetically distant communities can produce more biomass, likely, due to the presence of functionally divergent species, thus complementarily using resources. We suggest that plant phylogenetic relatedness should be considered for increasing success of future restoration projects.

0100.04 - Assessing ecosystem functioning in forests undergoing restoration

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Restoration projects may have broad and complex ecological goals, which in turn require distinct and integrative measures for evaluating restoration development and project success. However, most of studies usually evaluate only structural and species composition parameters, with little emphasis on ecosystem processes and functioning. The main objective of this study is to use an integrated approach that considers structural and floristic parameters as well as ecological processes and functional traits to evaluate and identify the parameters that most differentiate forests undergoing restoration and their reference sites. The study was performed in three 10 year-old restoration and three adjacent reference areas located in the South of Brazil. Sampling was performed in a total of 15-100 m² sample units per treatment, per site. We used data of adult trees, natural regeneration, litter stock, decomposition, detritivory and litter and soil C:N ratio. In addition we used a multifunctionality index to analyze differences and relationships with other parameters. Results showed several differences between treatments for the ecological processes, indicating that restoration has not yet achieved values similar to the reference ecosystem. Also restoration sites had lower values of vegetation structure, multifunctionality and species richness, but higher values of functional diversity. Moreover, even though values were lower for multifunctionality, differences towards reference sites were less pronounced than we expected when compared to values of vegetation structure, showing that ecological processes may recover even before the full recovery of structural complexity.

0100.05 - The need of trait-based frameworks for the restoration of ecological functions

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Most restoration programs around the world focus on reintroducing or favoring recolonization of species on degraded sites, expecting that restored communities would support the recovery of key ecological functions such as water supply, soil protection, and seed dispersal. Programs that do not explicitly target ecological functions may fail to restore stable communities that would provide ecosystem services to human well-being. Here, we aimed to review trait- and function-based restoration studies in the international literature. To identify the progress made in functional restoration ecology, we systematically reviewed Web

of Science database (2007-2016) using the following sequences of search words: 1) “restor* or reforest* or recover* or regenerat* or reintroduc* or refaunat*”, 2) “function* or service* or guild*”, 3) “trait* or attribute*”, 4) “tropic*”. We found 214 papers about restoration, from which 56% involved the reintroduction of native species. Most papers involved plants (74%), terrestrial habitats (89%), and non-tropical ecosystems (79%). Approximately half (52%) analyzed or discussed functions, 62% used traits, and 28% assessed both functions and traits. Only 12% of the papers used both functions and traits a priori, explicitly targeting them for restoration. Our review shows that trait-based restoration of ecological functions is an emerging approach that promises to be especially useful in the tropics, where restoration imposes major challenges to restore megadiverse ecosystems. We argue that trait-based frameworks that permit to quantitatively select subsets of complementary species in their provisioning of ecological functions will be useful for meeting the ambitious targets of restoration recently established by tropical countries.

0100.06 - Resource acquisition strategies of tropical dry forest tree species predict seedling performance in a large-scale Vertisol restoration project

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Integrating successional theory into the design of tropical dry forest (TDF) restorations could increase restoration efficacy, as recent studies have found early successional TDF tree communities generally have conservative traits. To determine if the successional stage of remnant vegetation controls the performance of tree species with different resource acquisition strategies, we planted a 6 ha experiment with trees that have conservative or acquisitive trait syndromes into two management treatments: clearing existing vegetation (early succession), or interplanting into existing vegetation (later succession). Twelve native species were assigned to acquisitive or conservative groups based on their functional traits (six species for each trait syndrome). In September 2015, on a degraded Vertisol site, we cleared three 1 ha plots, and left three 1 ha plots uncleared. Each 1 ha plot was divided into four 50x50 m split plots, and two replicates each of the species mixes (acquisitive/conservative) were assigned randomly to those plots. To quantify seedling performance we measured survival seasonally for one year. We hypothesized conservative species would have higher survival than acquisitive species in the cleared treatment because conservative TDF species are theoretically more adapted to early successional conditions. Our data were consistent with this hypothesis, as conservative species had 9.3% higher survival in cleared plots than acquisitive species ($p < 0.05$). Our results show that species with conservative traits have higher survival at early successional stages, which aligns with recent advances in TDF successional theory. Furthermore, successional and functional trait theory can aid in the design of TDF restoration projects.

S101 Restoration opportunities in urban and peri-urban areas

Organizer: Magda Liliana Chisacá Hurtado

S101.01 - Research and restoration in the andean city of Bariloche (Patagonia, Argentina)

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The increase and expansion of urban centers, is a great challenge for ecological restoration. The elimination of native vegetation and its replacement by exotic species, the opening of routes and roads without adequate planning and the increase in the number of quarries and their abandonment without recovery of the area, are some of the environmental problems to be solved in Bariloche. We evaluated the ornamental species used in the construction of live fences in the city; the vegetation established naturally in road slopes within and around the city; and the number of quarries and their condition (in operation, abandoned without rehabilitation or rehabilitation). We recorded 86 ornamental species in living fences, 74% exotic and 26% native. In road slopes, exotic species predominate and many of them invasive that modify the natural environments. Seventeen quarries were identified; 9 abandoned without rehabilitation and 8 in operation. We conclude that the planning and practice of restoration should be on the political agenda, in order to allow a planned, sustainable urban development that contemplates the conservation of biodiversity.

S101.02 - Challenges and opportunities of landscape restoration to recover peripheral urban zones in Latin America

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Latin America cities are experiencing an accelerated growth that can potentially increase the pressure over forested and natural protected areas. The Wildland urban interface is an important component of the landscape that can serve as a buffer to reduce the pressure over natural areas next to cities and can help to increase recreational opportunities for the people. In Latin America, many of those areas are currently deforested or severely degraded, thus affecting the access to recreation and access to natural areas. Different restoration interventions such as reforestation and agroforestry can serve as strategies to achieve sustainability goals (environmental, social and economic). In this study, we describe challenges and opportunities in a series of policy efforts from municipalities across Latin America to support restoration of wildland urban interface and their interaction with rural landscape restoration programs. The study focuses on cities in Guatemala Colombia, Peru and Chile. This is an effort in support of Initiative 20x20, a country led platform to bring under restoration 20 million hectares of degraded land in Latin America by 2020. Today, Initiative 20x20 has 49.7 million hectares of restoration pledges from 15 countries, three states in Brazil and three regional programs. The objective of the Initiative is to contribute to reduce and revert the land degradation process in Latin America and the Caribbean (LAC). This effort is in support of global land-restoration efforts of the Bonn Challenge and the UNFF New York Declaration.

S101.03 - A restoration vision for two territorial initiatives in Costa Rica

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The concept of Model Forests refers to permanent social platforms, with representatives of various sectors and interests, who seek the sustainable development and ecological functionality of a territory they share. Such territory or landscape must be large enough to have various forms of land and resources use and tenure, and in all cases it has several towns, urban and suburban areas. In Costa Rica there are two platforms of this type, in Guanacaste and Cartago, with areas of incidence and very

different populations, but in both the restoration of functions and services of ecosystems is a priority. This paper presents and compares both processes, their restoration challenges, motivations and strategies. It is concluded that, on a scale of landscapes with diverse human groups, a restoration that integrates elements of forests, agricultural rural landscapes and sub urban and urban contexts, not only depends on local will, it is a process affected by aspects of macro economy and markets. But that must arise from social and cultural concerns, along with analysis and planning processes, and from there political, institutional and financial processes, which allow the creation of an enabling environment for ecological rehabilitation actions, mainly those linked to productive spaces. Understanding the various local links between ecosystem functionality and the well-being of local people and other beneficiaries of their services is a key element in guiding and making restoration efforts more efficient and effective.

S101.04 - Water as organizer of the human area: complementarity between the water network and the expansion of the capital of the republic of Colombia

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The city of Bogotá D.C., was left without soil for its expansion. The need for growth leads to the use of land located north of its urban land, named Zonal Planning Plans (POZ), as a planning and management tool to develop areas adjacent to the city. To do this, it was sought that the water resource was the axis of physical ordering and development of the social and cultural dimensions. In this way a model of environmental and landscape sustainability was conceived in which each of the elements that make up the landscape managed to harmonize the physical spaces with the natural elements that are present in the territory. The model was structured based on the analysis of information related to the environmental supply of the POZ, resulting in the generation of an analysis of basic systems that interact in an urban ecosystem such as: the natural and social water component Coupled generates a public space for the enjoyment and conservation of water resources.

In this way three landscape models (MOP) are defined, which concretely improve the public and private spaces for first present in an urban planning, when seeking the urban sustainable development in the city of Bogota, framed in the following aspects; The Environmental Model, the Urban Model and the Water Model. The integrated models implement the interaction between flora, fauna, soil and water as a fundamental piece to allow the flow of energy and connectivity, as well as the mobility of the city, visitors and residents.

S101.05 - Landscape as support for cartagena heritage of humanity, and connectivity

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In 1994 Cartagena was declared a cultural heritage of mankind by Unesco, thanks to its colonial architecture and the walled complex, both legacy of a past rich in history and continental navigation. But that same wealth is not reflected in the city by means of a floristic wealth. In this sense and taking advantage of the construction of a road infrastructure that crosses the city from east to west, it was considered opportune to do in it a landscape project that articulates and connects the tree areas and gardens that in the mangroves, parks, pipes, green areas In the public space, lots in the private space and countless small clusters of trees within the manor of the apples are irrigated in the city: in this order of ideas, what was needed on a large scale was to have a structure that hierarchizes, orders and connects to the previous elements, which would be achieved through the main roads of the city and the pipes that cross it through the use of wooded profiles according to its hierarchy and the expansion, Respectively. In this way we would go from having a large hard infrastructure, impermeable, that fragments the corridors of ecological connectivity and increases the effects of urban heat island and transforms the urban ecological dynamics, to a consistent integrating elements and contributing to the improvement of biological conditions, Climate and environmental quality for citizens, according to the characteristics and global recognition that this city has.

S102 Decision-making towards the future: Policy drivers to enhance scaling up effective ecological restoration in tropical regions

Organizer: Rafael Barreiro Chaves

S102.01 - Are tropical Andean countries restoration-ready? Country-level policies and International commitments

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The development of ecological restoration (ER) among South American countries spans a broad continuum. At one end are Brazil and Colombia where there has been at least four decades of restoration science, practice and legislation. At the other end are countries where there has been little and scattered experience in restoration. While it is desirable that each country advances at their own speed and builds up its own path towards restoration, the levels of degradation are reaching a critical point and there is international enticement to set and meet restoration commitments quickly. However, the capacity to develop national restoration plans depends largely on the country's installed capacity in terms of technical capacity, infrastructure and legal and institutional frameworks. What is required to assist countries into formalizing and implementing restoration plans? In spite of major differences in experience and expertise in ER, Colombia, Ecuador, Peru and Bolivia share similar bottlenecks to advance towards national or international commitments. Some international NGOs are working with the countries to help them address these needs. However, ER is a complex process that requires a multi-scale and inter-sectorial approach. Thus, until major fundamental bottlenecks are addressed (such as territorial stability, adequate legal frameworks, and technical capacity or institutional and jurisdictional arrangements) external assistance is unlikely to be effective or derail the process. Just as a top-down approach for local restoration is unlikely to succeed; top-down assistance at national levels based on single-objective solutions is also likely to fail.

S102.02 - Ecology of natural forest regeneration and public restoration policies in human modified tropical landscapes

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Preserving the potential for natural forest regeneration (PNFR) in abandoned agricultural fields is priority for ecological restoration and for designing public policies for biodiversity conservation in human-modified tropical landscapes (HMLs). I developed a framework that considers the availability of propagules of native tree species and ecological disturbance regimes inflicted by agriculture, as two major determinants of PNFR at the field and landscape scales. The framework proposes that PNFR declines as size (Sz), duration (D) and severity (Se) of agricultural land use increase and forest cover reduce in the matrix. At the field scale, a simple ecological disturbance index ($EDI = Sz + D + Se$), constructed with information provided by farmers, predicted better PNFR than agricultural land use type (applied previous to abandonment) and than measurements of soil and microclimate conditions taken at time of abandonment, particularly when fields were close to seeds sources (i.e. forest remnants). At the landscape scale, tree density, species diversity and biomass of secondary forests sharply declined as a modified EDI index (weighted by relative cover of agricultural fields, old-growth forest remnants and second-growth forest patches in the landscape) increased. The proportion of landscape covered by fields undergo harsh agriculture (e.g. cattle pastures) was a stronger predictor of PNFR than the proportion covered by old-growth forest remnants, which suggest that environmental limitations imposed by disturbance inflicted by agriculture are relatively more important than the availability of species sources in the landscape. Based on these results, I offer recommendations for designing public policies for restoration and conservation of biodiversity in HMLs.

S102.03 - Building reliable restoration policies: The importance of monitoring and the value of integrated online systems

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Many are the bottlenecks capable of hampering the plans of the numerous countries that have committed themselves to restore millions of hectares within their respective territories encouraged by international agreements and inter-linked concerns about loss of biodiversity, ecosystem functionality, and ecosystem services. One of the most common bottlenecks is neglect of the importance of monitoring. Defining clear indicators and expected results is crucial to bring reliability to public policies addressing how to achieve restoration goals at a national or subnational scale. A consistent monitoring framework can simultaneously: a) foster transparency regarding results of ongoing commitments assumed by governments and institutions; b) improve certainty as to the effectiveness of the initiatives, reducing the risk that a given ecosystem undergoing restoration will return to a degraded condition in the future; and finally c) provide a secure environment for public and private investments in bigger and more relevant projects at landscape, regional, and national scales.

Based on the experience of implementing the Ecological Restoration Supporting System (SARE) in the state of São Paulo (Brazil), and also on the interface with the Atlantic Forest Restoration Pact (AFRP), we analyze how online monitoring systems can be powerful tools to achieve restoration goals. We also propose a model through which existing public policies are taken as a basis to build a robust restoration framework. In our case, this approach is used to integrate online project registration and monitoring systems to guide planning and scaling up of effective ecological restoration.

S102.04 - The importance of social outcomes for restoration success: The Umzimvubu catchment and other case studies from South Africa

CHRISTO MARAIS; MICHAEL BRAACK; HARRY BIGGS; MIKE POWELL

The Mzimvubu catchment in the Eastern Cape Province of South Africa is currently undergoing a series of developments. Two large reservoirs are part of the Mzimvubu Water Project led by the Department of Water and Sanitation. On completion they are intended to supply potable water to 730 000 people, irrigate about 2900 ha and power a small hydropower plant. In order for these reservoirs to be filled with good quality water, to avoid sedimentation and other problems which dramatically reduce the lifespan of the dams, it's essential to have healthy upstream ecological infrastructure.

Occasionally opportunities come together to create an exciting "flagship project". The Department of Environmental Affairs invests in the catchments around the proposed reservoirs and is planning to further restore land for at least the next 8 years, besides investing in research, with an important focus on the social context. The catchment is known for rural poverty and land degradation, one where locals could act on building a more sustainable future, by improving ecological infrastructure.

The vision for the rehabilitation is "to support sustainable livelihoods for local people through integrated landscape management that strives for resilient social-ecological systems and which fosters equity in access to ecosystem services." The Expanded Public Work Programme teams are spearheading environmental improvement in various ways (e.g. invasive alien plant clearing; land and wetland rehabilitation; appropriate fire management).

The presentation will focus on the successes and failures of the programme to date, lessons learnt and what is needed to ensure sustainability.

S102.05 - Old tools revisited and some new ones: what's needed to scale up effective restoration in the tropics and elsewhere?

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Looking back at some of the most commonly cited conceptual models in restoration ecology, we seek to identify essential elements required for the scaling-up and mainstreaming of restoration in the 21st century. We argue that the reference model concept is particularly important when scaling-up restoration, and present a framework to assist in the realization of long-term, adaptive, consensual, and effective restoration policies and programs, at the landscape- and larger spatial scales, in the tropics

and elsewhere. Also, we suggest it is useful to consider both ecological restoration and ecological rehabilitation as members in a ‘family’ of restorative activities to be deployed to at large spatial scales, along with remediation, and recuperation of production, transport, distribution and exploitation systems. In addition to maintaining biodiversity, we must address and develop ways to make our land, water, and other resource uses more ecologically, economically, and ethically sound and sustainable. In conclusion, we present a new model that could help orient if not actually design planning, monitoring and evaluation, scaling-up, and applying restorative activities in new areas. We compare it with frameworks embedded in the SER International Standards document and the Global Partnership for Forest Landscape Restoration programmatic work. Our audience is government and private sector investment policy-makers looking for long-term gains in terms of benefit cost ratios.

S103 Ecological restoration: a strategic path for large landscape conservation?

Organizer: Harvey Locke

S103.02 - Global restoration initiatives as a mechanism for large landscape conservation and vice-versa

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Since their emergence in the 1980s, the fields of conservation biology and restoration ecology have developed along similar trajectories in terms of sphere of influence and rate of growth. These fields, however, often operate in silos, without taking advantage of integrative and synthetic opportunities. Conservation biology has historically emphasized wildlife over vegetation, used observational rather than experimental approaches, and focused on protection of high-quality habitat rather than ecosystem repair. On the other hand, the science and practice of ecological restoration is grounded in vegetation and soil science, largely uses experimental approaches, and focuses on implementation of activities in degraded habitats. Although there is strong agreement that both approaches, protecting existing organisms and habitat and repairing degraded areas that fragment the landscape, are required for successful conservation, lack of communication and integration of efforts has led to inefficiencies in practice. For example, successful ecological restoration requires adequately providing for all trophic levels, including species that require large connected habitat areas, such as some large carnivores; however, often critical habitat areas for wildlife are not used in landscape-scale restoration planning. With increasing investment in ecosystem restoration to meet global challenges like the UN Convention on Biological Diversity Aichi Targets, there is a need to draw from the efforts of the large-landscape conservation movement. Similarly, current landscape-scale restoration initiatives provide a strategic opportunity for the large landscape conservation movement to further its goal. This presentation will explore opportunities and challenges for integrating efforts between these two disciplines.

S103.03 - Restoring process in Gravel-bed Rivers for the ecological health of mountain landscapes

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Rivers are essential to the life requirements of a wide variety of aquatic, avian and terrestrial species in the valley systems and mountain landscapes of western North America. More than just conduits carrying water or channels used by fish, gravel-bed rivers create high diversity of habitat, concentrate nutrients, and form a complex network of lineal corridors of connectivity linking populations of species from microbes to grizzly bears. In their natural form and function, gravel-bed rivers are the most important feature for Nature in these mountain landscapes. Yet, in most mountain systems river floodplains are the first to be converted to permanent human settlement and infrastructure. Dams, diversions, gravel mining, transportation, municipalities, and agriculture cause human-mediated constraint and loss; and thus threaten river-floodplain ecological health. An emergent property of gravel-bed river floodplain structure and function clearly shows that maintaining normative hydrogeomorphic processes are essential to sustaining spatial and temporal dynamics of river and floodplain habitats and regional biodiversity and biocomplexity. River management strategies that focus on restoring process over structure is a paradigm shift in conservation priorities and practice that must be forthcoming in the 21st Century as we seek to sustain our Natural heritage and ecological health of mountain landscapes.

S103.04 - Three conditions for considering ecological restoration strategically in a large landscape conservation context

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Ecological restoration could be a critical ingredient of large landscape conservation (LLC). The purpose of LLC is to protect all native biodiversity at the gene, species and ecosystem level in an interconnected way so that they remain viable through allowing the natural processes they depend on to continue and be resilient to stressors such as climate change and can provide natural ecosystem services. The terrestrial world is in three different conditions: largely intact, fragmented but with big blocks of habitat, and highly threatened where endangered species are concentrated. LLC is primarily applicable to the first two. In the regions that are largely intact, the primary focus should be on keeping them that way and ecological restoration is relevant at the process level such as reducing or eliminating the effects of large dams upstream and restoring forest cover to ensure continued release of aerosol particles to create rainfall on which the system depends. In the more fragmented world, a mosaic of approaches to conservation is needed. Strategic ecological restoration with the big picture in mind could restore degraded blocks of habitat, restore connectivity where it has been severed, and restore natural processes such as fire and flooding. Here both process and pattern are goals for ecological restoration depending on social context and function in the large landscape strategy. In highly threatened ecosystems, ecological restoration will necessarily be focused on survival of endangered species but could also be done with an eye to restoring natural process that link out to larger landscapes.

S103.05 - Connectivity Conservation – the Architecture for Large Scale Ecological Restoration

GARY MARTIN TABOR

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The global ecology of the planet may be undergoing a threshold state shift. Rapid changes in climate and diminishing abundance of biodiversity are challenging the planet's resilience capacity to respond to large-scale human and natural disturbances within historical ranges. Protected area conservation strategies remain the cornerstone of saving nature; yet many protected areas exist as ecological fragments in a matrix of incompatible land and marine uses. Connectivity conservation is an emergent conservation practice that complements and expands the ecological functionality of protected areas. Connectivity conservation as a restoration tool optimizes limited resources and time in re-establishing landscape and seascape integrity and serves as the green architecture for large scale restoration. In recognition of the growing practice of connectivity conservation, the World Commission on Protected Areas has established a new global Connectivity Conservation Specialist Group. This presentation will highlight the priorities and opportunities of this community of 21st Century conservation practice.

0104 Recovering soil properties

0104.01 - Mixing residues allows multiple benefits beyond proper stabilization of tailings storage facilities at closure: the case of organic residues from intensive pork productive systems

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Mine closure regulations require proper physical and chemical stabilization of post-operative tailings storage facilities (TSFs). Stabilization of TSFs may be achieved by chemical, physical, or plant based technologies. It has been demonstrated that plant-based technologies (i.e. aided phytostabilization) effectively reduce erosion, assure chemical stability, and reduce environmental risks of metals. However, in the case of large scale TSFs (> 300 ha), massive amounts of organic amendments are required to speed up soil formation and assure self-sustainable plant formations. The use of massively produced organic residues (agroindustrial, depurative) in aided phytostabilization of TSFs, that would be otherwise landfilled or improperly disposed of, may be an opportunity to solve broader environmental problems with larger socio-environmental impacts. A good example of this application includes the use of biosolids as tailings amendments. In the present study we evaluated the efficacy of solid fractions (SFPS) of pig slurries produced by an intensive pig farm in central Chile, after mechanic and aerobic-aeration treatment, as treatment plants share territory with TSFs. A laboratory assay was defined; increasing doses (0, 25, 50, 75 t ha⁻¹) of SFPS were incorporated into copper mine tailings stabilized for 15 days and sown with *Lolium perenne* var Belinda (bioindicator). After 42 days, plant performance (shoot/root biomass; metal content in shoots) was evaluated. Dose-dependent and significant increasing yields were found for shoots and roots. Although pig residues have high copper and zinc contents, metal content in shoots were below toxicity values described for animals and no phytotoxicity symptoms were observed in plants

0104.02 - How long it will take to recover soil properties after forest restoration?

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In the last years, forest restoration efforts have been increasing in tropical landscapes such as the Atlantic Forest of Brazil, leading to important changes in physical and hydraulic characteristic of soils and also in carbon stock that may influence hydrological processes. However, the response and extent to which forest restoration can affect these soil properties is still poorly understood. To bridge this gap, we studied the effects of forest restoration on some soil properties in six small catchments in Campinas municipality, São Paulo State, Brazil. In all catchments, we monitored soil properties at two depths (0-10 and 10-20 cm) in three land cover types: a remnant forest patch, pasture and a forest restored using high-diversity-mix of plantings (85 regional native species) of 9 years of age. We found higher bulk density, and lower macroporosity and carbon stock values in the restored forest, suggesting a considerable memory effect in these areas, as a result of intense land use prior to the restoration actions. The surface hydraulic conductivity (Ks) was higher in the restored forest compared to remnant forest and pastures. Our results suggest that to understand the Ks in the land cover and its hydrological consequences, more studies with different laboratory and field measurements of Ks are important. We conclude that 9 years of forest restoration can slightly recover soil properties, however to achieve the remnant forest levels will take probably more than a decade.

0104.03 - Biotic and physicochemical factors in a soil in restoration in San Felix (Bello, Antioquia, Colombia)

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The study of complex ecosystems such as soils includes their innumerable life forms. Soil characteristics are decisive in restoration processes and are evaluated according to the dynamism of certain periods and activities. This study was conducted in the Bello municipality (Antioquia, Colombia), at 2,550 m.s.n.m and with an annual rainfall of 1756 mm, whose soils are mostly derived from volcanic ash. The land was subjected for a long time to livestock activities and for more than two years has been under a process of passive and assisted restoration. The Berlese method yielded samples of meso and macroorganisms, which were identified to order by taxonomic codes. The soil physicochemical properties include apparent density of 0.56 g.cm⁻³, which is related to low compaction, elevated acidity and high percentages of organic matter. The analysis of biotic factors was done with the Ecomorphological (EMI) and Soil Biological Quality (QBS) indices. EMI values between 1 and 20 indicate good adaptation of the individuals to the soil environment. A QBS of 106 let presume that the soil has been restored passively but efficiently. In a little more than two years the land has a remarkable vegetative development. Soil quality has been determinant in the restoration process and studies continue to monitor the succession of forest biodiversity and edaphic behavior.

0104.04 - Soil nutrients in the northern Australian wet season driven by cyanobacterial carbon and nitrogen pulses

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Grazing is the major economic activity in Australia's savannah grasslands and shrublands that cover >1.9 million km² of which about half are degraded. Restoration and grazing management strategies in Australian landscapes are dependent on natural ecosystem services that promote sustainable land use. Cyanobacteria as ecosystem engineers are an integral component of the northern Australian savannah where cyanobacterial biocrusts cover on average 28% of soil-plant interspaces. The core focus of the northern savannah research has been based around the function of cyanobacteria within the soil-plant ecosystem and their role as ecosystem engineers. In this project, we quantified soil C and N pulses in terms of seasonal cyanobacterial biocrust productivity over two years (2009-2011). There is no biocrust productivity during the dry season even if it rains. In the wet season, once a threshold of 40% relative humidity is reached cyanobacterial growth is initiated. From mid-November to mid-April (typical wet-season) cyanobacterial CO₂ uptake resulted in a total carbon gain equivalent to ~10% savannah soil carbon. Bioavailable N derived from cyanobacteria was significantly correlated with species richness throughout the wet season. Bioavailable N production followed well-defined seasonal trends. Synchronisation in productivity demonstrated that given the presence of cyanobacterial crusts was significant in these landscapes, they provided a critical addition of soil nutrients in the northern savannah. Management strategies such as timed wet-season resting of grazed lands will promote soil fertility facilitated by cyanobacteria. Natural ecosystem services provided by cyanobacteria will assist in the restoration of ecosystem function.

0104.05 - Coal waste as the main constituent of a soil substitute

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Often, mining activities destroy soils to such an extent that entire areas are left with limited environmental quality, reduced plant growth and lack of nutrient cycling. Sustainability in coal mining is a field of increasing scientific and technological interest; among possible routes to achieve such a goal is the interaction between environmental restoration and waste management. This understanding leads to the possibility of using coal mine waste as a substrate (soil) for plant growth, leading to a reduction in waste volume and its associated environmental impacts as well as a reduction in the need of soil extraction from borrow pit areas for reclamation activities. The objective of the present study was to cultivate and characterize, chemically

and biologically, a soil substrate made from a mixture of desulfurized coal from Santa Catarina State/Brazil and three other industrial wastes: steel slag (alkalinity source), sewage sludge (organic matter and nutrient source) and rice husk ash (physical structure component). The substrate was kept vegetated for two years with *Avena strigosa* (Lopsided Oat) as the first crop, and *Lolium multiflorum* (Ryegrass) as the last. Results showed chemical properties adequate for plant growth (fertility), available metals within legal limits (EPA 3050), and a microbial community in the process of establishment measured through microbial respiration. It is possible to reduce environmental damage and risks caused by coal and industrial waste disposal whenever an integrated approach is undertaken.

0104.06 - Soil constraints and ecological restoration in New Zealand

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The relationship between biodiversity and soil biogeochemistry provides a focus for the work described in this paper. The context is the demand for an essential synchronization of land use for agriculture and ecology in contemporary landscapes in which soils have been profoundly modified in a relatively short space of time. Vegetation clearance and burning by Polynesians in New Zealand was followed by European introduction of ungulate grazing, cultivation, new plant species, fertilization and irrigation. In terms of current and future soil management practices, farming requires productivity improvements whilst conservation requires soil suitable for growth of native species. These appear to be two quite different drivers of land management that occupy the same area of land or which overlap. The challenges for ecological science lie in improving very limited knowledge of how to grow, protect, expand and sustain native floral, faunal and microbial communities and functioning ecosystems on soils that have been eroded and chemically modified, and in the presence of invasive weeds and mammalian pests. Case studies in South Island are described that include (i) a conversion of plantation forestry to intensive irrigated dairy, (ii) restoration of a coastal sand plain forest impacted by mining and agriculture and (iii) high country pastoral land challenged both by production and ecological conservation. The necessity for a rigorous application of scientific knowledge is emphasized in this paper which uses a soil-centric approach to draw attention to the likely erroneous assumptions underlying current agricultural and ecological management of soils, with proposed workable solutions.

0105 Mitigation: rivers and watersheds

0105.01 - Water and Forest Governance in Brazil: the case of the integration of environmental agendas in the Doce River Watershed

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The water availability is a priority factor for the Doce River watershed. In this context, the region is emblematic: in less than 50 years it suffered losses of natural resources due to a model of unsustainable economic development, which led to a high degree of water compromise and severe conflicts over water use. In view of this scenario, an interesting partnership was created between Instituto BioAtlântica (IBIO), Rio Doce Watershed Committee, The Nature Conservancy Brasil (TNC) and Espírito Santo State Government, through Reflorestar Program. This partnership aims to (i) concentrating technical efforts, (ii) constructing viable alternatives to contribute to water availability in the watershed, and (iii) increasing the scale of ecological restoration actions. The goal is to recover 1.500 hectares of the Atlantic Forest, in 600 rural properties in Doce River region in the Espírito Santo State. Planned actions include the elaboration of the CAR (Rural Environmental Cadastre), Ecological Restoration Projects in each rural properties, and the labor of the rural producers themselves as a counterpart to the investments. This initiative has as a differential the leverage of public and private economical budgets, allowing to meet in large scale the expectations of various stakeholders, each with varied agendas in the Doce River. To date, more than 400 farmers have been served in this partnership, making this experience a case of great relevance for environmental governance of watersheds, with effective results and lessons learned.

0105.02 - Erosion and Sedimentation: A Restoration Experience in the Panamanian Tropic

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In Panama, a number of major projects have recently been developed, such as Panama Canal Expansion (completed), highway construction, hydropower and the current construction of an open pit copper mine. Panama has an average precipitation between 2,000 and 6,000 mm of annual rainfall, this massive land movement under precipitation conditions and fragile soil type has shown the need to implement effective and practical erosion controls that prevent or reduce the negative impact of sedimentation as part of efforts to restore ecosystems in the areas affected by the development of the infrastructure projects mentioned, so that erosion control for this presentation will be based on bioengineering such as low impact protection techniques of water courses and as an additional complement the reforestation to the restoration of degraded areas by wildfires and agricultural activity as to highlight the restoration work carried out in Panama.

0105.03 - Reclaiming habitats in the drawdown zones of hydroelectric reservoirs

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The drawdown zone of a hydroelectric reservoir is a challenging environment for plants and animals, particularly when the annual change in reservoir elevation averages 25 m. Flooding and flow alteration resulting from reservoir operations combine to create complex disturbances that can modify entire ecosystems, particularly in the drawdown zone. To mitigate for the varied effects of reservoir operations on habitats in the drawdown zone of Kinbasket Reservoir in southeastern, British Columbia, BC Hydro implemented a 10-yr, reservoir-wide restoration program to enhance sustainable vegetation growth to benefit ecological and social values. The objective of the program is to understand how reservoir operations affect existing vegetation communities and whether various mitigation measures can increase the cover and diversity of vegetation growing in the drawdown zone and improve wildlife habitat suitability. To date, methods used include plantings of live-stakes and sedge plugs, removing accumulations of wood debris from the shoreline and wetlands, installing log booms around sensitive habitats, and the creation of habitat features using wood debris and local substrates to increase topographic heterogeneity. A summary of work conducted between 2007 and 2016 highlights some of the challenges associated with a program of this magnitude, particularly as they relate to the somewhat predictable, but varying effects of changing reservoir elevations. The results to date of the various revegetation prescriptions, physical works trials, and vegetation and wildlife effectiveness monitoring projects are summarized and a discussion of the data gaps and lessons learned is provided.

0105.04 - Erosion control activities in mining construction projects. An alternative to prevent erosion in body waters during the mining projects construction

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The construction of large mining projects demands a large movement of land and machinery, inevitably causing major impacts. In Latin America, world-class mining projects have been developed in environmental conditions that differ greatly among countries. The present study aims to recommend the most appropriate erosion control practices during the construction of mining projects, especially with "open pit", in order to prevent and reduce erosion problems. Main erosion problems were identified in different mining projects in the high Andean areas (Peru), as well as in tropical areas (Panama), where this study was carried out. Physical and biological methods, sometimes associated with soil loss, have been tested; chemical compounds (flocculants and coagulants) have been used in one of the mines due to the size of the particles, while forest and grass species have been used for surface soil stabilization. We concluded that the fundamental principles for erosion control in the entire construction process consists of: a) Preserving the existing vegetation as much as possible; b) Reducing the erosive power of water; c) Respecting the constructive sequence of the project; and d) Compacting every structure that is built and carry out immediately the revegetation efforts. Recommended practices for erosion control and slope stabilization include the use of materials and/or engineering designs. The most appropriate techniques according to the geographical scope and project type, as well as the constructive sequence that should be followed to avoid major environmental impacts will be presented.

0108 Restoration of coastal vegetation

0108.01 - Restoration of dunes and estuaries on a dynamic coastline: Principles and lessons learnt from the east coast of South Africa

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The South African coastline is a simple, uninterrupted one and can be recognizably described using four straight lines. Although micro-tidal with only a 2m amplitude, the open nature of the coast, a narrow continental shelf and offshore storm events result in periodic storm surges. This combination results in a highly dynamic coastal environment characterised by both onshore/offshore as well as longshore sediment movement. Appreciation of the nature and inevitability of these processes and their very real significance for coastal developments has not been an obvious feature of planning. Related to coastal sediment dynamics is the behaviour of estuarine mouths in this eastern region where highly seasonal rainfall and concomitant low flows allow sandbar accumulation, mouth closure and inundation of the floodplain or 'backflooding' which can extend the estuarine habitat to the 5 AMSL contour, well beyond normal spring tide high water levels. Despite the lessons of the past and costs associated with development in these dynamic zones, coastal developments continue to be placed in areas where they may be regularly at risk of significant damage and in some cases complete destruction and in areas causing declines in estuary health. These poor decisions are compounded by inappropriate restoration measures including the artificial establishment of dunes within dynamic beach or even intertidal zones, breaching of estuary sand-barriers during naturally closed periods and revegetation of previously estuarine habitats. Examples of these as well as suggested more appropriate restoration approaches will be presented.

0108.02 - Performance of "chinampas" an innovative, nucleation-based, restoration technique for mangrove forests: a case study in the Gulf of Mexico

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Mexico is one of the top countries by mangrove-covered area but also presents high rates of mangrove loss: 9.6% year⁻¹ from 1981-2005 and 1.2% year⁻¹ from 2005-2010. To reverse this negative trend, several official projects have used direct planting of seedling or nursery trees, but this approach doesn't consider key physical settings such as geomorphic or hydrologic features. In this work, we assess the performance of a prehispanic-inspired technique: "chinampas" ("cane grid" in náhuatl language) in restoration sites with different age (2012, 2014 and 2015) in Alvarado Lagoon System, Veracruz. Chinampas increase land availability while coping with flooded lands and emulate a nucleation process. We measured vertical and horizontal growth of intervened sites and analyzed trends of change at landscape level with high resolution aerial imagery (<10cm) by direct tree counting and measurement and aerial drone overflights. Survival was 74%, 83%, 81% and 86% in the 2012, 2013, 2014 and 2015 treatments respectively and total height of plants was 0.87 m, 1.5 m, 2.64 m and 2.48 m. Area of mangrove patches was 60 m² ha⁻¹, 572 m² ha⁻¹, 2180 m² ha⁻¹, and 1544 m² ha⁻¹. Area, perimeter, perimeter-area ratio and radius of gyration of the mangrove patches in the chinampas show an exponential trend model and reflects an active nucleation pattern. Our results suggest that applied nucleation is a feasible approach for mangrove restoration. Landscape geometry measures could be part of practical methodology for assessing the performance of mangrove restoration techniques.

0108.03 - Methodology for the restoration of a mangrove forest impacted by landfills and constructions in urban areas

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An area of 79,886m² of mangrove forest located in the municipality of Joinville, Brazil, was landfilled in the 90's for the allocation of buildings and deposits. Brazilian legislation required the restoration of the mangrove forest. The difficulty of transporting sediments through urban areas required an alternative of local verticalization of the sediments (rubble mountain, Trümmerberg), leaving about 30,000m² as a new mangrove. After the execution, the area presented: artificial channels, mangrove in restoration, remaining mangrove, Lowland Ombrophilous Forest, rubble mountain, parking lot, workshop area and the Environmental Education Center. In order to restore the abiotic threshold, we excavated channels, created the flood areas and the rubble mountain, the latter with structure formed by a dam for the containment of soft soil deposited within. This structure has internal gabion drains to percolate water from the saturated soil. The biotic threshold in the low areas suffered a passive restoration through the daily tide variation. We restored the elevated areas through the seeding of native herbs, shrubs and trees, creation of superficial roughness and bird perches, transposition of soil litter. We restored the social threshold through the construction of tracks reaching all local environments, the transformation of a building into an environmental education center on mangrove dynamics and a reception for students and local visitors. The site has become an observation and learning center on the formation of secondary mangroves and a model for the restoration of other areas with similar impacts. The area is being monitored for at least 5 years.

0108.04 - Oak regeneration in U.S. Atlantic maritime forests: Similar symptoms, multiple causes

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The causes of oak regeneration failure differ from region to region, between species, and are often driven by multiple interacting factors. Maritime Live Oak Hammocks, a coastal forest type in the southeastern U.S., face present and future environmental stressors that differ from the past, including: climate change, increased storm frequency, aquifer depletion, fire suppression, and herbivore pressure. Land managers on Georgia's barrier islands are concerned that these factors are causing regeneration failure of the iconic live oak, *Quercus virginiana*. To assess regeneration trends, we surveyed several 2ha maritime forest stands with varying land use histories on two Georgia barrier islands, recording the spatial distribution, size, and several associated environmental variables for mature trees and seedlings of all tree species. Mature tree composition varied with land use history, but the largest differences in oak regeneration were between the two islands. On one island, there was almost no recruitment of any oaks, while on the other island, laurel oak (*Q. hemisphaerica*) seedlings and saplings were common while *Q. virginiana* recruitment was virtually nil. Even though the two barrier islands are physiographically similar and only few miles apart, and both appear to have live oak regeneration failure, they show different syndromes of regeneration failure, which will likely lead to different trajectories of forest composition change in the future. Site-specific restoration strategies will require deeper understanding of the specific stressors that limit regeneration in each case. We discuss our use of interviews with coastal managers to guide and complement our ongoing research.

0108.05 - Restoration of the Baltic Boreal coastal meadows in Estonia: The long-term experiment on different management regimes' influence on rare plant *Gladiolus imbricatus* population

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The Baltic Boreal Coastal Meadows are a declining habitat around the Baltic Sea and the largest and most consistent meadows can be found in Estonia. Therefore the focus of the European Union according to this habitat type is directed to Estonia and its success in maintaining and restoring these communities is crucial.

The total area of the coastal meadows in Estonia is 18000 ha, but only 8000 ha are under management or restoration. The abandonment is the main threat to these meadows and the main type of management has historically been extensive grazing. A rare plant species *Gladiolus imbricatus* is growing in South-Western part of Estonia on these meadows. The species is typical for floodplains and wet meadows.

In 2001-2005 a large number of meadows were undertaken for restoration, especially fighting the reed. Heavy grazing was introduced and mainly landscape level and rare bird species and amphibians were targeted. In 2002 four different restoration areas with remnant *G. imbricatus* populations were selected to monitor the population dynamics. The mowing, grazing with sheep and cattle and abandoned areas were selected for experiment. The counts were made in 2002-2004 and 2014-2016. The results show clearly that population numbers of *G. imbricatus* decline in course of grazing activities and abandonment and only mowing is favourable for the populations. The presentation will analyse in detail the restoration start-up effect on the juveniles, prematures and generative shoots, as well as long term patterns of the populations behaviour. The conservation dilemmas will be analysed.

S109 Serendipity vs Strategy: The Necessity for a National Native Seed Strategy

Organizer: *Peggy Olwell*

S109.01 - National Seed Strategy: Getting the right seed in the right place at the right time

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Extreme weather events are increasing in frequency, intensity and impact across the United States. With Hurricanes Sandy and Matthew in the East and serious drought conditions and altered fire regimes in the West, ecological restoration practitioners must be able to respond quickly to landscape-scale ecological changes with appropriate native seed resources. The National Seed Strategy provides a plan for restoration of public and private lands at all scales and a coordinated approach for federal, tribal, state, and private entities to develop and deliver genetically appropriate plant materials for restoring resilient native plant communities and sustainable ecosystems. It guides coordination of efforts to achieve four major goals: (1) Assess seed needs and ensure the reliable availability of genetically appropriate seed reserves, (2) Identify basic and applied research needs and conduct research to aid users in seed sourcing to meet current and projected future conditions and to improve technology for seed production and ecological restoration, (3) Develop science delivery tools and monitoring applications that will enable managers and practitioners to make timely and informed decisions for ecological restoration, and (4) Formulate plans for internal and external communication that engage all stakeholders. The Strategy ultimately benefits landscapes by supporting ecosystem services provided by native plant communities. Implementing the Strategy through collaboration between botanical and emergency preparedness sectors and building botanical capacity at the regional, state and local levels will enable the US to restore degraded ecosystems and build ecological resilience and adaptation in response to extreme weather events.

S109.02 - Regional Native Plant Projects - The Great Basin Example

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The U.S. National Seed Strategy provides impetus, direction and support for new as well as established regional native seed programs across the country. Collaborative programs initiated by the Bureau of Land Management in the Great Basin, Mojave Desert and Colorado Plateau of the western United States address restoration needs resulting from drought, wildfire, invasive exotics and the effects of increasing population pressure. The Great Basin Native Plant Project is representative with an overarching objective of increasing the availability of native plant materials and providing the technology required for their use. Project goals reflect those of the National Seed Strategy: 1) Assess seed and research needs to improve restoration capabilities; 2) Increase knowledge of genetic variability within species and develop seed transfer zones; 3) Develop cultural practices for seed increase of herbaceous species; 4) Devise appropriate restoration strategies for re-establishing diverse native communities; 5) Facilitate science delivery and application; and 6) Improve communication among all members of the restoration community and the general public. Progress in the Great Basin requires local understanding of species, plant communities and environmental constraints encountered in conducting revegetation. In addition to facilitating efforts of native plant projects at all scales, the National Seed Strategy is also increasing public awareness of the value of native plant communities, the magnitude of revegetation needs and the necessity for collaboration to address these needs.

S109.03 - Meeting the New York City region's native seed demands in a post Hurricane Sandy World

EDWARD TOTH

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The greater New York City region presents an extremely challenging set of conditions from which to facilitate rapid responses to natural and man-made disasters. 2014's Hurricane or "Super Storm" Sandy resulted in landscape-scale ecological changes throughout the region with estimated damages exceeding \$75 billion US dollars. This talk will present the complex political, bureaucratic, physical, and ecological environment within which responses had to be formulated and enacted at a scale and speed never experienced in the region before. The storm has also spurred extensive planning and development efforts aimed at mid- to long-term projects to dramatically improve the resiliency of the built and natural environment to future catastrophic events. Virtually every one of these efforts has or will have a component requiring genetically appropriate plant and seed resources for stabilization, rehabilitation and restoration projects that will have to be staged across complex lines of jurisdiction. The talk will focus on what resources are in place to meet those challenges, current efforts to scale up those resources to provide a region-wide, coordinated mechanism for anticipating, and meeting plant needs, as well as the impediments and challenges encountered that are requiring innovative approaches to solutions. Lastly, the talk will examine those aspects of the National Seed Strategy that are most readily addressed in the mid-Atlantic and those most in need of new ideas, new partnerships and new influxes of dollars, as well as how a national strategy will aid implementation at the regional and local levels.

S109.04 - The Southeastern Grasslands Initiative (SGI): Ensuring the Survival of Temperate North America's Most Biodiverse, Most Endangered, and Least-Appreciated Ecosystems

LARRY DWAYNE ESTES

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The southeastern U.S. is not generally known as a major grassland region but that's because its grasslands largely disappeared nearly two centuries ago. Dr. Reed Noss, renowned conservation ecologist of the University of Central Florida, termed them the "Forgotten Grasslands of the South." Today's remnant savannas, prairies, glades, barrens, and wet grasslands are vestiges of a bygone era. Many are imminently threatened by fire suppression, habitat loss, invasive species, and climate change. In spite of occupying less than 1 percent of the land area, southeastern U.S. grasslands harbor a disproportionate percentage of the region's biodiversity, including hundreds of endemic and globally rare taxa and globally rare communities. As grasslands continue to slip into oblivion, the effects of ecological collapse are becoming painfully evident. Without a paradigm shift and swift intervention, hundreds of species of plants, small mammals, birds, and insects, face functional or complete extinction in mere decades. A stark realization is setting in that past and current conservation efforts aren't enough and a new visionary approach is needed to re-think grassland conservation on a big-scale. The Southeastern Grasslands Initiative (SGI) has been established as a clearinghouse to identify priorities and focus future conservation efforts for southeastern U.S. grasslands across 23 states and nearly two-dozen ecoregions, stretching from Texas to New Jersey and from Oklahoma to Florida. To ensure Southern grasslands not only survive, but flourish into the 22nd century and beyond, SGI will employ a multi-faceted approach that combines restoration, preservation, re-creation, research, seedbanking, consultation, education, and market-driven strategies.

S109.05 - The role of botanic gardens in native seed research and use

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Throughout the history of botanic gardens, research has been an important part of their activities. More recently, with the recognition of the extinction crisis facing us, the missions of many gardens have embraced conservation and restoration roles. Many gardens have developed seed banks to provide plant material for reintroduction and restoration. With core competencies in ecology, plant identification, and horticulture, botanic gardens are well positioned to provide expertise necessary for successful restoration projects. Our own restoration research has focused on a diverse portfolio of projects, including studies of “native winners” (native species that compete well with weeds), provenancing and seed zone delineation work, and research related to benefits of diversity at many levels (genetic, functional, phylogenetic, and phenological).

0110 Climate change and ecological restoration

0110.01 - Ecological restoration during a time of rapid environmental change: How do we keep up with a runaway train?

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One of the greatest challenges facing the practice of ecological restoration in the 21st Century is the rapid pace and global scale of current and projected environmental change. There are many sources for these changes to the environment – conversion of ecosystems to other types and uses, habitat fragmentation, declines in species populations, extinctions of species, the human assisted movement of species from their original ecosystem to new ecosystems on a global scale, pollution, and global climate change. Almost all of these changes are either directly or indirectly related to continuing growth and movement of the human population. Restorationists have been aware of these changes for many years but only recently have been able to fully grasp the rapidity and scale of environmental changes. Given our current understanding of the rapidity and ubiquity of environmental change, it becomes obvious that the goals and practice of ecological restoration must change in order to accommodate the shifting conditions on the ground. Ecological restoration must be conducted with an eye to the future, planning for ways for the restored site to adapt as the environment around it changes. Restoration can help us keep up with accelerating rates of change if we: 1) maintain biodiversity, ecosystem structure, composition and function; 2) reduce the effects of disturbance and environmental stress; and 3) nurture or create refugia, redundancy and connectivity among ecosystems. Broad-based, forward looking restoration will be vital tool as we respond to environmental change and prepare ecosystems for the future.

0110.02 - A systematic review of ecological attributes that confer resilience to climate change in environmental restoration

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Ecological restoration is widely practiced as a means of rehabilitating ecosystems and habitats that have been degraded or impaired through human use or other causes. Restoration practices now are confronted by climate change, which has the potential to influence long-term restoration outcomes. Concepts and attributes from the resilience literature can help improve restoration and monitoring efforts under changing climate conditions. We systematically examined the published literature on ecological resilience to identify biological, chemical, and physical attributes that confer resilience to climate change. We identified 45 attributes explicitly related to climate change and classified them as individual- (9), population- (6), community- (7), ecosystem- (7), or process-level attributes (16). We summarize the attributes and their relationship to restoration principals in a decision support table and provide three example applications to illustrate how these classifications can be used to prioritize climate change resilience attributes for specific restoration actions. We suggest that (1) including resilience as an explicit planning objective could increase the success of restoration projects, (2) considering the ecological context and focal scale of a restoration action is essential in choosing appropriate resilience attributes, and (3) certain ecological attributes, such as diversity and connectivity, are more commonly considered to confer resilience because they apply to a wide variety of species and ecosystems. We propose that identifying sources of ecological resilience is a critical step in restoring ecosystems in a changing climate.

0110.03 - Best practice restoration: building the evidence base for restoring Eucalypt woodlands of southern Australia

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The principal management intervention used to combat biodiversity declines associated with land degradation is ecological restoration. However, there are valid concerns that sub-optimal restoration interventions are jeopardizing outcomes, which brings into question our capacity to reach new global targets (e.g. The Bonn Challenge aspires to restore 350 million ha by 2030).

The management of plant genetic resources and inconsistent monitoring of projects are recognized impediments to optimal restoration outcomes. I address these knowledge gaps by embedding experiments in restoration projects to test the relationship between plant fitness and seed origin (e.g. three empirical case studies of the provenances of six Myrtaceae species spanning 2.5 degrees of latitude (ca. 460 km) in southern Australian Eucalypt woodlands). Although I determined that the study species persisted in a range of climatic conditions by combining specific adaptations to aridity and acclimating to environmental change via phenotypic plasticity I also found sub-optimal plant performance was common, and signals of local maladaptation occurred in 2 of the 3 empirical studies. I found that persistence was strongly directional (e.g. arid to mesic). Furthermore, plant performance indicated the genetic diversity harboured in non-local provenances may be harnessed to counteract plant fitness concerns (e.g. adaptation lags due to climate or lack of connectivity due habitat fragmentation). The synthesis of this work supports the use of embedded experiments to derive evidence-based approaches for iteratively improving restoration practices. Networking the results more broadly is likely to be the most expedient path to achieve best practice restoration and enable resilient project outcomes.

0110.04 - The importance of species selection and seed sourcing in forest restoration for enhancing adaptive capacity to climate change: Colombian tropical dry forest as a model

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Tree-based restoration of degraded areas is a global priority. An important, but often overlooked, aspect of ensuring the success of restoration projects relates to the selection of appropriate forest reproductive material (FRM), at least for active restoration activities that involve tree planting. As a minimum condition, FRM should be selected to (i) correspond to the restoration objectives, (ii) be well adapted to survive and thrive under the degraded site conditions and (iii) have sufficient genetic diversity to ensure the potential to adapt to changing conditions in the future. Using seasonally dry tropical forest in Colombia as a model, here we present a scalable map-based online tool available at www.restool.org, which is intended to assist restoration practitioners with the identification of appropriate tree species and sources of FRM. Decision making combines information on (i) suitability modeling under current and future climate conditions; (ii) the intended future use of the forest under restoration; (iii) locally prevailing stress conditions; (iv) functional trait diversity of tree species; and (v) the genetic quality of FRM. In the selection of tree species priority is given to more than 300 species for which information about its propagation is available, which will be compiled in an illustrated book that will be available in physical and virtual format. Acknowledging that restoration has different, audience-specific meanings and interpretations, our tool is intended to support the decision making of anyone interested in planting trees on land that is suitable for seasonally dry tropical forest for whichever purpose.

0110.05 - Managing climate risk in ecological restoration through use of seasonal forecasting

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Ecological restoration has widely variable outcomes from successes to complete failures and there are diverse perspectives on the factors that influence the likelihood of success. However, not much is known about how people perceive these factors to be effective, how their perceptions influence their actions, and whether their perceptions match reality. We sought to answer what influences people on how they invest in restoration, specifically whether risk influences how they plan and implement restoration projects. We surveyed 307 people involved in the restoration of native vegetation across Australia to identify their perceptions on the factors influencing the success of restoration, and on the approaches employed to plan, implement and monitor restoration projects and associated costs. We found there is a mismatch between realised risks and planning considerations. Despite climate (particularly lack of rainfall and drought) recognised as the main risk limiting the success of restoration projects (sometimes resulting in failure), climate is not a major perceived risk nor is selecting species adaptable to climate change considered to be an effective factor in improving success. This mismatch highlights the need for better consideration of climate risks in restoration. We are investigating the use of seasonal forecasting to manage climate risks in the planning and implementation of restoration projects, using the City of Gold Coast, Australia as a case study. We are identifying the forecast

product that would be most beneficial to restoration practitioners, and testing its benefit to improve decision making and restoration outcomes through better management of climate risk.

0110.06 - Grassland restoration: Influence of soil homogenization on plant community resilience to soil freezing

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Recently abandoned croplands provide opportunities for restoration of biodiverse grasslands. However, it is unclear to what extent uniform soil conditions caused by a legacy of tillage (soil homogenization) may limit the availability of distinct microsites needed to support high species diversity. Limits to species diversity could in turn affect plant community resilience to periods of stress. We used a restored tallgrass prairie in Ontario, Canada to test if the addition of distinct soil patches (microsites) would increase plant community resilience to frost stress. Soils with added sand and woodchip patches were compared with soils where sand and woodchips were added and mixed to mimic homogenization; half were exposed to increased soil frost via snow removal and the other half experienced ambient snow cover. Each treatment was assigned to a plot within ten randomized complete blocks. Quadrats were used to survey density and percent canopy cover of each plant species. Responses to frost stress were dependent upon plant functional group. Adventive legume cover decreased in homogeneous sand treatments and was stable in heterogeneous sand treatments, the same trend was observed for adventive forb cover, but in woodchip plots. The opposite occurred with native forb cover, which decreased in woodchip heterogeneous plots with snow removal but remained stable in the homogeneous woodchip treatment. These results suggest that frost stress can impact plant functional groups in soil microsites in diverse ways, and efforts to increase the diversity of soil microsites during restoration may increase resilience of plant communities to stress.

0112 Advances in using indicators in restoration ecology

0112.01 - Are we there yet? Capturing the diversity of reference states and setting usable restoration targets.

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Restoring degraded ecosystems is one of the largest research challenges of our time, and developed nations are taking up the challenge by tackling an increasing fraction of their restoration needs every decade. However, restoration is explicitly directionless without concomitant understanding of end-states, targets and reference systems, and this has been a fast consolidating field over the last 15 years. It is now widely accepted that using a single reference state as a restoration target inadequately captures the complexity in real ecosystems, rather the target for restoring sites should be any point in a cloud of acceptable conditions, developed from a range of reference states. Species composition targets are explored using a case study of large-scale restoration in an ecologically diverse and complex system, where not only does more than one vegetation type represent a viable end-state but multiple habitats represent viable end-states within these vegetation types. Ecosystem function targets are explored using a global meta-analysis, which highlights difficulties in their use as reference systems in that many measures of ecosystem function remain unchanged across long restoration trajectories. Finally, in setting regulatory standards it is pragmatic to use a simple, widely-accepted metric for restoration targets. The challenges involved in choosing a simple metric and an objective target which is an accurate indicator of the level of restoration in complex ecosystems are discussed, and a solution proposed.

0112.02 - Success evaluation of restoration projects integrating ecological, structural, socio-economic and political indicators. Experiences and developments.

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Future restoration activities can be improved if their success is properly evaluated. Assessing the outcome of river restoration projects facilitates adaptive management and can increase the efficiency of future restoration projects. A large variety of indicators has been developed and used to evaluate success regarding ecological and structural objectives of restoration. There is, however, a lack of clearly measurable socio-economic and political indicators. Such indicators are needed to ensure sustainable restoration management and to develop success evaluation schemes that integrate all of these dimensions. We use the following data sources to analyze indicators and modes of integration : 1) data from a national survey of all restoration activities (in all habitats) in Norway since the year 2000; 2) data from a paper review of projects describing evaluation of restoration success in Europe/North America since the year 2010; and 3) an existing concept for integrated success evaluation of ecological, structural and socio-economic aspects for the case of river restoration in Switzerland (Woolsey et al. 2007).

Based on the findings and the existing body of literature on the topic will we develop recommendations on an encompassing spectre of socio-economic and political indicators and their potential integration in future success evaluation schemes.

0112.03 - Toward a phytometer approach in restoration ecology: How to use plants as indicators of restoration success?

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As stated by the SER Primer, a key attribute of successfully restored ecosystems is their capacity to sustain viable populations of target species. Common monitoring programs based on habitat surveys detect whether or not this goal is met by stating the presence of certain species. In case of missing species, however, the surveys fail to explain the underlying site or dispersal limitation. The use of phytometers is an alternative method capable of verifying these processes. As it is a relatively new approach, standards for its application remain to be defined. Thus, we aim at improving this method with respect to the choice of species and plant traits. We planted three target and two non-target species in restored montane peatlands in Germany, and exposed the plants to two water levels with different peat quality in a greenhouse experiment. Many plant traits were measured and statistically related to each other as well as to light, water and soil conditions. Plant biomass and flower number were the most variable traits and therefore could be useful to assess a wide range of abiotic conditions. There was a high correlation between diameter, height and biomass of the phytometers as well as between growth and reproduction. We conclude that the most straightforward and accurate traits should be chosen. As species show different responses to habitat conditions, a careful selection is necessary, while the use of several phytometers, including non-target species, increases the explanatory power of the restoration monitoring.

0112.04 - Application of scientific knowledge and São Paulo State policies in the assessment and monitoring of large-scale ecological restoration in the Atlantic Rainforest and Cerrado, Brazil

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Committed to comply with environmental requirements, Suzano Papel e Celulose proposed to carry out the environmental regularization of 4,234.80 hectares of Permanent Preservation Areas (PPA) subdivided into 3,329 polygons (sizes mean 1.28 ± 1.54 Ha) belonging to 101 properties located in São Paulo, Brazil. Distributed within a radius of 200 km, these areas cover different phytophysognomies of Atlantic Rainforest and Cerrado biomes, in several states of environmental degradation and conversion of areas with eucalyptus plantations to native vegetation. Given this complex panorama, this study presents a large-scale evaluation carried out over two years with the purpose of assessing the PPAs and suggest management recommendations aiming at the ecological restoration. The assessment consisted in remote landscape pre-classification and field verification, both qualitative and quantitative of almost all polygons (80.3%). In areas whose eucalyptus has already been removed (2,382.95 Ha), passive restoration was the most indicated technique (92.0%). These areas present high richness and abundance of native species, possibly due to favorable forest matrix and high resilience. Other areas require more intensive managements: reforestation (21.71 Ha), partial reforestation (89.58 Ha), "rework" (77.99 Ha). Based on São Paulo State legal policies (Resolução SMA 32/2014, Portaria CBRN 01/2015), a restoration areas monitoring plan was proposed through the definition of 93 homogeneous groups of polygons. Results indicate that large-scale restoration demands the use of different techniques suitable for each environmental situation. In addition, monitor discontinuous areas requires a thorough evaluation in how to group them preserving an ecological sense, but also economical and logistic feasibility.

0112.05 - Indicators of forest restoration for environmental monitoring of the state of Mato Grosso, Brazil

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Brazil's revised forest law (2012) defined areas for forest restoration that each federation unit should refine according to regional particularities. Some Brazilian states are modifying the laws to monitor forest restoration, stopping verification of the implantation techniques and instead verifying the performance results. For example, the state of Sao Paulo established that forest restoration is achieved when canopy is 80% closed, there are 3000 saplings per hectare and 30 or more tree species are present on a given number of parcels. This work presents examples of forest restoration indicators in 57 areas restored by different restoration techniques in the state of Mato Grosso to be compared with those established indicators. The areas were sampled in the Xingu/Araguaia region, in central Brazil. Two 4m x 25m plots were installed to evaluate plants larger than two meters and later subdivided in two 1m x 25m areas: one for evaluation of canopy cover and the other for regenerating density, (regenerating >0.3 and <2.0 m in height). To evaluate crown coverage, the point-interception monitoring method was applied. The results suggest that many areas reached the minimum values required in Sao Paulo for the seventh year indicators. The richness of regenerating species is a difficult indicator to achieve with the planting of seedlings and direct seeding techniques, however, it may be achieved by natural regeneration in resilient areas. Direct seeding promotes canopy cover and regenerating density, while planting seedlings quickly forms a canopy but does not reach high regenerating density.

0112.06 - Use of a multivariate approach to measure the success of ecological restoration

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An important step in the restoration process is monitoring and subsequent evaluation of the need for additional interventions, called adaptive management. The monitoring approach will depend, among other factors, on the scale of the project and its objectives. With a focus on the restoration of ecological processes, a model was elaborated for the identification of reference values and for the generation of adaptive management recommendations for restoration areas of Fibria Celulose S.A. in Bahia, Espírito Santo and Minas Gerais States, Brazil. A total of 1,090 samples of 100 m² were plotted in restoration areas with ages between four and five years, and also in old restoration areas where the main activity was the elimination of exotic species. In these samples, based on the Protocol of the Pact for the Restoration of the Atlantic Forest, the following parameters were measured: density of regenerating and adult individuals, regenerant richness, canopy cover of arboreal or shrub species, invasive herbaceous cover and average canopy height. Five homogeneous groups were identified based on a multivariate approach using cluster analysis. Facing the patterns observed in the groups, discriminant linear functions allowed identifying the similarity of the ecological conditions of the groups. One of the groups presented a pattern consistent with that expected for restored areas. This group was segmented according to age and restoration methodology to generate reference values for the Fibria's Restoration Program. This analysis also allowed the identification of adaptive management actions required for the restoration areas belonging to the other groups.

S113 Linking research and practice in ecological restoration in Latin America: where are we? Where should we go?

Organizer: Juan Camilo Garibello-Peña

S113.01 - Identifying gaps for the practical science necessary to restore sustainable ecosystems in Colombia

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Demands of ecological restoration in Colombia are huge given the percentage of degraded land at the most populated regions and ambitious goals as part of international commitments like the 20X20 initiative. As the response to these demands requires a strong basis of research, we assessed the national development of restoration ecology using a framework that proposes practical science necessary to restore biodiverse and sustainable ecosystems. We searched for publications and postgraduate theses using Scopus database and Google scholar. With Scopus we use *restor*and Colombia*, for english, and *restaur*and Colombia* for spanish. With Google scholar we use *restoration ecology and Colombia* in combination with either surname of well-known researchers or name of national journals. We found 150 studies. Most of them (37%) addressed description of reference ecosystems and ecological succession whereas sustainability of restored ecosystems and their integration at a landscape scale was the aim of 25%. Conditions for seedling growth and survival was addressed by 17% and only 16% and 7% addressed sourcing of propagules and seedling establishment respectively. Our survey shows a deficit in the necessary knowledge to use promotion of natural regeneration and seeding as main strategies to accomplish restoration goals. Likely, this deficit is related with the traditional approach in which planting trees has been the most important restoration strategy. Accomplish goals by this mean is unrealistic given the prohibitive cost of producing seedlings at the required scale.

S113.02 - Ecological restoration in Argentina, twenty years of research (1996-2016).

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Ecosystem restoration is a global and national priority for the recovery and conservation of ecosystems. Ecological restoration (theory and practice) should consider the participation of different disciplines and approaches to achieve resilient, sustainable and diverse ecosystems. The objective of this work was to evaluate the thematic of the publications developed in Argentina. By means of the Scopus database, we performed two literature searches, one in Spanish (*restau * and Argentina*) and the other in English (*restor * and Argentina*). Between 1996 and 2016, 130 publications were registered, 87% about basic research and 13% active restoration. In basic research there is an important contribution of different disciplines, however the works of active restoration mainly evaluate the optimal conditions of establishment and growth of plants. We consider that it is also necessary to work on the identification of reference sites, monitoring goals, origin of the material used (seeds, plants, soil seed banks), as well as to evaluate the resilience, diversity and ecosystem processes in the restored sites.

S113.03 - Applied science for ecosystem restoration in Mexico: State of the art and perspectives

FABIOLA LOPEZ; CRISTINA MARTÍNEZ-GARZA; ELIANE CECCON

Restoration ecology is a scientific discipline which develops principles to guide the restoration of ecosystems based in ecological theory. Despite a global increase in restoration research, in some regions, there is a gap between the needs of knowledge for restoration practices and the current outputs of restoration science. The objective of this review is to synthesize the current situation and the perspective of the restoration ecology in Mexico and the challenge of this area of research given the international commitments that Mexico has acquired. A review of scientific publications, meetings, institutions, researchers and the offer of

restoration training programs was carried out. This review resulted in a total of 195 restoration articles from which 79% were research articles, 17% opinions or methodological proposals and 4 % were meta-analyses. In the 82% of the publications, the first author was working at a Mexican institution and from them, the 57% were men and 43% women. Forest ecosystems represented 71 % of the studies and the principal topic was the recovery of woody species. Our evaluation identified applied research gaps to implement effective landscape restoration practices. The results showed that there is not enough offer of practical restoration training programs. The need of a national scientific policy of restoration and long-term sources of funding is discussed.

S113.04 - Restoration in Costa Rica: 30 years of research (1987-2016)

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Located in Central America, Costa Rica is part of the Central American Isthmus, a bridge that joins North and South America. Its topography, two littorals, and diverse microclimates contribute to a globally recognized high biodiversity hotspot. Agricultural development and land use change led the country to lose much of its forest cover. The objective of this work was to compile publications on restoration conducted in Costa Rica. A search in Scopus using the terms “restor * Costa Rica” and “restaur * Costa Rica” was made, it found a total of 152 articles published from 1987-2016. An 89% of them corresponded to terrestrial ecosystems, 10% to political issues and 1% to marine ecosystems demonstrating the global trend on terrestrial ecosystems research. The terrestrial ecosystems research focused on sustainability, resilience & landscape integration (57%), material sourcing (11%), and targets and planning (9%). Other important topics were related to the political agenda, including environmental education and payment of environmental services. This compilation constitutes an important baseline of knowledge from different scientific areas to develop the discipline of restoration in Costa Rica, while putting in evidence gaps on information. This review will contribute to current commitments in conservation, project implementation, and training of human resources in restoration.

S113.05 - Perspectives and the current situation of Ecological Restoration in Ecuador

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The practice of ecological restoration in Ecuador is an emerging but very dynamic activity in recent years. Here I address the progress of this discipline based on three aspects: (1) conceptual and theoretical foundations, (2) scientific know-how and (3) legal instruments.

(1) Evidence shows that the modern ecological restoration concept was used by Acosta Solís in the 1970s. Later in the 1980s, it was included into legal instruments that are still in force, with the aim of regulating activities to recover conditions that favor the evolution of natural processes and environmental services. (2) The generation of scientific knowledge has increased strongly during the last decade, focusing on the analysis of natural regeneration and floristic characterizations of habitats. However, studies exploring factors that limit restoration processes and the role of wildlife in restoration practices are still scarce. The dry ecosystem of Galapagos is where greater efforts of restoration have been undertaken, followed by Andean forest ecosystems. (3) The development of political and legal instruments has allowed the establishment and institutionalization of ecological restoration practices in the country. This is apparent as the declaration of Nature’s restoration rights in the Political Constitution of Ecuador and the goals of restoring fragile ecosystems raised in the National Plan for Good Living. These concepts are being implemented in the territory since 2013 based on the creation of specific economic incentives aimed at the voluntary restoration of degraded ecosystems

S114 Forest restoration for the support of livelihoods and generation of ecosystem services

Organizers: Kurt von Kleist & Liz Ota

S114.01 - Identifying timber species for biodiversity conservation, livelihood enhancement and financial risk mitigation in smallholder tropical reforestation

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In smallholder tropical reforestation fast-growing exotic species are often favoured. One of the reasons for this is that exotic species present a lower-risk higher-return investment than native ones. Besides the availability of silvicultural knowledge and superior planting material, timber markets of exotic species are frequently better structured and stable than those for native ones. Identifying native tree species with similar or lower financial risk that can bring similar or higher financial returns than exotic species is of great use for both conservation of local biodiversity and for the enhancement of livelihoods. This study focused on smallholder experiences in the Provinces of Biliran, Leyte and Southern Leyte, the Philippines, to address the question: What frequently used species have the potential to provide income while reducing financial risks from smallholder reforestation? This question will be addressed by comparing the potential financial outcomes of seven native species and four exotic species commonly grown in the Philippines using the Modern Portfolio Theory. For the model used, tree growth parameters were defined based on data sets from three reforestation projects, surveyed from 2005 to 2012. Financial and silvicultural parameters were defined based on key-informant interviews, farmer interviews and literature review. The parameters were included in the model and Monte Carlo Simulations were performed to predict timber production and the probability distribution of financial results for each of the 11 species. The results can provide an indication of species on which to focus when developing smallholder reforestation systems aimed at providing financial return and risk mitigation.

S114.02 - Connecting the local with the global: participatory monitoring in forest restoration

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Global forest restoration initiatives present an unparalleled opportunity to reverse the trend of land degradation and participatory monitoring could play a crucial role in providing accountability, generating local buy-in and catalyzing learning in monitoring systems. A recent review we carried out confirms that local people can reliably collect accurate data on forest change, drivers and threats. However, there must be sufficient local incentives and support, including orienting the restoration activities to meet local goals and priorities. Successful participatory monitoring systems can quickly generate information that is adequate to answer the questions and needs of local stakeholders – not necessarily scientifically rigorous data. A scalable, multisite forest restoration monitoring initiative (i.e., that also includes national level aspirations) should have a small number of indicators shared by all possible sites, with the flexibility to determine other indicators to respond to local needs. It should emphasize the creation of learning networks to facilitate the connection of stakeholders at multiple levels with the information they need for decision making and social learning. This presentation is expected to generate discussion and debate on how to meaningfully link local and global restoration aspirations.

S114.03 - Shortcomings in the Philippines' National Greening Program and their impacts on biodiversity rehabilitation

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Efforts to increase forest cover for improving ecosystem integrity are often at odds with reforestation activities benefiting smallholder livelihoods. This creates significant challenges in the implementation of reforestation programs aimed at accommodating multiple stakeholders. Nonetheless, attaining a balance in this apparent disparity between biodiversity support and livelihood needs is fundamental in achieving the multiple benefits of large-scale reforestation endeavors. We employ case study methodology to investigate species-utilization, identify obstacles hindering the use of more seedling diversity and, explore solutions to improve forest restoration initiatives in the Philippines. In 2013, 176 species were recorded in reforestation projects in Region 8 (Visayas and Samar), but 75 percent of all seedlings planted were from 17 of those species. Of nearly 700 projects implemented in 2013/15, where species richness was recorded, 84 percent were implemented with five species or less. Three main categories emerged from interview data that obstruct the incorporation of more species in reforestation plantings: 1) focus on attaining acreage targets; 2) non-adherence to sound community-based forestry practices and; 3) poor biodiversity rehabilitation goals in regulator frameworks. These findings demonstrate that species diversity issues are intertwined with broader contexts such as current infrastructure, program emphasis, and human needs. This entanglement precludes improvements to species diversity from occurring in isolation; addressing technical hurdles alone will not improve diversity issues on the ground. We make several recommendations to improve species availability and advance reforestation outcomes altogether.

S114.04 - Improving livelihoods and the environment through forest restoration: Lessons from a pilot project in Biliran, Philippines

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This paper outlines the design and implementation of a pilot reforestation project in Biliran, Philippines. The area reforested had been the site of at least four previously unsuccessful reforestation attempts over the past 20 years. The pilot project drew on past reforestation research and experiences to identify 'best practice'; especially in respect to community engagement and capacity building processes. The paper first describes the how the incorporation of livelihood activities was a central part of the strategy for reforestation. We then describe the reforestation activities that comprised of tree planting for both restoration and timber production. Finally, we outline ten key lessons that we have learnt from the pilot project and outline our plans for future expansion.

S114.05 - Creating local restoration capacity, reconnecting indigenous communities to their roots and building a restoration-based rural economy: Grassroots experience from a major tiger reserve in India

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Bandipur National Park is a Protected Area and Tiger Reserve located in one of the world bio-diversity hotspots namely Western Ghats in India. A number of indigenous communities live at its periphery; mostly relocated from within the national park when it was formed in 1973. Disconnected from the forests, these communities lead a subsistence existence dependent on temporary work in nearby agricultural farms. Their traditional ecological connection is also fast fading, raising a risk of future conservation efforts suffering from inadequate stakeholder capacity and involvement. Junglescapes (www.junglescapes.org), a grassroots ecological restoration non-profit, has been working for the last nine years on addressing these concerns through a community-participative model of restoring degraded forest ecosystems. Restored landscapes were buffer forests connected to the National Park wherein all restoration activities including project planning were carried out with active participation of community members. Restoration methodology encompassed both active and passive methods with an emphasis on low-cost techniques implementable by the community. Over 1000 hectares of degraded forests were restored to healthy habitats marked

by revival of ecological cycles, improved vegetation and wildlife resurgence. Key community-related outcomes were sustainable alternate livelihoods, improved community custodianship of their ecology, revival of traditional ecological knowledge and creation of local stakeholder capacity for restoration, which are in line with IUCN principles. Community teams and leaders evolved naturally providing effective indigenous stewardship, while youth involvement facilitated generational transfer of knowledge. Importantly, this model demonstrated a viable alternative that addresses the dual contemporary objectives of conservation and sustainable development.

S115 Restoration of tropical and subtropical grasslands and savannas: from seed limitation to seed introduction

Organizer: Gerhard E. Overbeck

S115.01 - Grassland restoration in the Tropics and Subtropics: Broad-scale factors determining vegetation recovery

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Restoration of tropical and subtropical grasslands and savannas is a recent topic compared to restoration of forests. Only recently have distinct ecological features of these systems and their relevance for restoration been recognized, e.g. the importance of regeneration from below-ground organs or the role of disturbances that characterize these 'old growth grasslands'. Empirical restoration studies are still scarce, which impedes generalization of findings from single studies. Here, we present results from a literature review of restoration experiments in tropical and subtropical grasslands and savannas. Based on this, we suggest that restoration aims, techniques as well as outcome depend to a large extent on productivity level of the system. In low productive systems with very slow plant development, including difficulties in recruitment and thus natural recovery, restoration is a big challenge, and few success stories exist. While introduction of target species appears as an important restoration technique in general, vegetation management already in early restoration phases seems important in productive systems. This is especially the case when invasive species are part of the degradation situation and where adaptive management approaches are necessary to control invasive plants and to enhance the native component of the plant communities under restoration. The available studies also indicate that the clear distinction between active and passive restoration – made in forest restoration – cannot easily be applied to grasslands. Apart from testing of techniques, future research should focus on functional approaches, on adaptive management and on monitoring, considering specific restoration goals in different restoration phases.

S115.02 - What happens to the seeds in Cerrado?

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Restoration of the herbaceous layer is one of the challenges for Cerrado restoration. Until now, few projects had success in restoring tropical grasslands and savannas and one of the reasons is the lack of knowledge about seed production/traits and seed bank dynamics. Although species produce a high amount of seeds, the seed bank shows a very low number of seeds, with low species richness in comparison to the aboveground vegetation. Graminoid species usually disperse their seeds during the rainy season, whilst most forbs and shrubs have a peak of seed dispersal during the dry season. Poaceae species for example, show a high production of seeds, but several species (e.g. *Axonopus pressus*) can have >60% of empty seeds and nearly 80-90% of nonviable seeds. Other grass species show physiological dormancy, which is not broken by temperature fluctuation. Some Fabaceae species, which regularly produce seeds, can have up to 50% of their seeds predated, being thus not found in the seed bank. In an area under natural regeneration for 18 years, the amount of seeds found in the seed bank is <150 seeds.m², being composed mostly by seeds of invasive species and few grass species, such as *Gymnopogon foliosus*, which is an annual grass. Therefore, natural regeneration through the seed bank in Cerrado should be complemented by other actions and the use of seeding should target species which do not present dormancy, produce a high amount of viable seeds that can germinate fast, before they get predated or not viable.

S115.03 - Hay transfer and litter removal in restoration of areas degraded by pine plantations in highland grasslands of southern Brazil

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Highland grasslands in the southern part of Brazil's Atlantic forest biome are species-rich ecosystems, with high endemism. Since the late 90s, large parts have been afforested with exotic tree species, transforming the landscape, and causing biodiversity losses. After clear cutting, original vegetation does not establish spontaneously. This study aims to test restoration techniques to overcome possible propagule and site limitation using a bi-factorial design. Factor 1: Surface preparation at four levels: I -litter removal; II - litter removal and soil scarification; III - litter removal by fire; IV - control. Factor 2: Hay transfer: I - Hay application in late spring; II - Hay application in late summer; III - Hay from late spring and late summer; IV -control. Results of one year experiment showed a larger vegetation cover where litter has been removed and significant increase in plant species richness in hay treatments ($P < 0.05$). For factor 1, control and litter removal by fire treatments exhibited the lowest vegetable cover among treatments. Treatments with hay have had a greater contribution from the Poaceae and Asteraceae families (dominant in the reference areas). Treatment of soil surface by litter removal and soil scarification promoted a great colonization of Cyperaceae species, indicating that possibly this treatment does not lead to a vegetal composition that comes close to the reference areas. Our preliminary results indicate that the physical barrier of the litter is a limiting factor for the colonization of the areas and that hay introduction provided an increase in the species richness.

S115.04 - Invasive species control and seed introduction for restoration of subtropical grasslands, southern Brazil

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Invasive species are one of the major challenges on ecological restoration. In Campos grasslands, C4 African grasses threaten biodiversity and ecosystem services. However, there are not experiences with ecological restoration for these ecosystems and we need to test the viability of techniques normally used in others grassland ecosystems. This study aimed to test different combinations of techniques for the ecological restoration in grasslands invaded by *Urochloa decumbens* in Campos, Southern Brazil. We combine two techniques to control invasive species (herbicide application and topsoil removal) and two techniques to introduce native species (hay transfer and direct sowing). We established nine blocks in a bi-factorial experiment on Morro Santana, Porto Alegre, Rio Grande do Sul, combining two factors and each one with three treatments (two techniques plus the control). Both techniques of invasive species control have shown to be efficient to reduce the invader cover, as well as to allow the establishment of native pioneer species. By the time of the first evaluation (eight months) the herbicide application revealed to be a better treatment than topsoil removal, once plots with herbicide had lower invasive species cover and higher species richness. But we are still monitoring the results. The species introduction techniques however failed to efficiently add native species to the community composition and to compete with *U. decumbens*, specifically native grasses. In addition, we observed a clear relationship between the invader cover and the presence and coverage of native species. Thus the control of invasive species is fundamental to further vegetation recovery.

S115.05 - Challenges to restore extreme grassland ecosystems: seed contribution now and beyond

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The challenges facing the restoration of mountain grasslands in the tropics are paramount. Harsh weather (high daily variation in temperature, high uv-radiation), strong seasonality, nutrient poor soils, and fire, are few of the challenges that plants must overcome to get established and thrive in restored sites. The rupestrian grasslands are perhaps the most extreme ecosystems of the Cerrado of Brazil and the one that must be restored urgently due to the loss of biodiversity and ecosystem services caused

by global changes. We report on the experiments done on hay transfer, soil transfer, and sapling transplantation into degraded areas. Hay transfer resulted in low success, as seed set of most species appeared to be low and often unviable to be able to promote restoration success. Soil transfer resulted in some success but topsoil transfer often lead to weed and untarget species colonization and remains complicated to set up in the field at large scale. Plant species propagation from seedlings into the restored sites showed better potential. 8.5 year monitoring of transplanted individuals of ten shrub species indicated that survival, growth, and recruitment varied over time. While some species exhibited great mortality during the last four years of observation, they also showed great resprouting ability and new seedling production. Most of the studied species showed remarkable ability to adapt to the extreme environment of the degraded area, persisting either through surviving or recruiting new individuals. In constrained environments, survival and recruitment capacity should represent criteria to select species for restoration project.

S115.06 - Dry and wet grasslands: different factors influencing restoration success

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Tropical Grassy Biomes (TGBs) have suffered biophysical degradation in the whole world, but their restoration is still challenging for scientists and practitioners. Considering that direct seeding, hay transfer, topsoil translocation, transplanting and assisted natural regeneration have been successful to restore temperate grasslands, we tested the potential of these techniques to recover wet and dry grasslands in the Neotropics (Cerrado vegetation in Brazil). We used old growth grasslands – OGGs as sources of propagules (donor sites) and verified their resilience after the extraction. In terms of richness and vegetation cover, transplanting provided the best and direct seeding the worst results for both wet and dry grasslands. However, wet or dry grasslands differ in the ecological factors and ecosystem processes behind restoration success or the resilience of donor sites. We obtained better results in wet compared to dry grasslands for all restoration techniques tested. Soil water availability stands out, therefore, as a major factor driving restoration success. Proximity of seed sources provided successful colonization of wet grasslands, while not fostering natural regeneration of the dry grassland. We observed fast recovery of both dry and wet grasslands after propagules extraction, an evidence of high resilience in the donor sites. The major mechanisms promoting natural regeneration, however, were distinct: seed rain in the wet grasslands and re-sprouting from underground organs in the dry grasslands. Restoration of Cerrado grasslands can be successful using OGGs as propagule sources. The best technique to apply in each site, however, will depend on ecological factors acting locally.

0116 Restoration of temperate and Boreal Forests

0116.01 - Environmental and ecological footprint of seismic lines in Alberta: Restoration and mitigation strategies

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Continuous growth of the oil and gas industry throughout the boreal forest of Alberta, Canada, including exploratory activities, has led to an increasing focus on the environmental and ecological impacts of this development. A major feature of oil and gas exploration is the construction of seismic lines across the landscape, including forests, open areas, uplands and peatlands. These seismic lines are used to delineate bitumen reservoirs prior to extraction. Historically, seismic lines were up to eight metres wide and extended for many kilometres. More recently, new practices have significantly reduced the width, and corresponding anthropogenic footprint of seismic lines. However, seismic line density has increased drastically, and construction of seismic lines is expected to continue at a high pace in Alberta. I provide an overview of environmental impacts and restoration efforts of seismic lines over the past several decades in Alberta. I review documented scientific evidence of seismic impact on environmental factors, including soil, permafrost, hydrology, biogeochemical factors, snowmelt, and microclimate, as well as edge effects, which extend into the habitats adjacent to seismic lines and enlarge the disturbance effect. I then discuss the responses of plants and wildlife to environmental conditions altered by seismic lines. I compare recovery processes across different habitats, and between historical seismic lines and more modern low impact seismic lines. I summarize current regulations and practices with respect to seismic line restoration and reclamation, and suggest potential mitigation strategies to minimize negative impacts of seismic lines on the environment.

0116.02 - Ecological restoration in a coastal temperate rainforest: Tackling the environmental and social consequences of destructive logging in Oregon's Siuslaw National Forest to implement durable solutions

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Political gridlock seized the Pacific Northwest in the 1990s after decades of aggressive logging and associated losses of old growth forests which imperiled, notably, northern spotted owls (*Strix occidentalis caurina*) and salmonids (*Oncorhynchus* spp). Following litigation and court-ordered injunctions, the federal government issued a comprehensive plan aimed at species protection and habitat restoration, relying on modeled but untested solutions. Would the new plan succeed biologically and socially? The Siuslaw National Forest in Oregon's Coast Range is among the world's most productive forests, both in terms of its capacity to grow wood as well as wildlife and fish habitat. Decades of focus on timber production came at a cost to other forest resources and environmental services. The abrupt cessation of commercial logging provided an opportunity to consider hoped for restoration opportunities and achievements under the new plan.

A legacy of mono-culture plantations of Douglas fir (*Pseudotsuga menziesii*) dominated the landscape -- about 40 percent of federal land -- as well as a dense network of logging roads (1.3 km per 100 hectares) in very steep terrain subject to landslide and failure in heavy rain events. Restoration efforts focused on commercial tree thinning in plantations to attain accelerated old-growth characteristics, road closure and mitigation measures to reduce risk of storm damage, and stream habitat restoration to improve salmonid spawning success and juvenile fish survival.

After 20 years of focused restoration efforts, monitoring results indicate dramatic results on all fronts.

0116.03 - Establishment of planted trees and native vegetation on compacted mine tailings

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On older reclaimed mine sites, both compacted soils and aggressive non-native pasture grasses and legumes can compete strongly with planted tree seedlings, hindering reforestation efforts. Successful tree establishment has been seen on sites where compaction is relieved by deep ripping herbicide is used to control ground cover, but herbicide treatments are expensive and may have a negative impact on planted trees. An experiment was established to test two native ground cover treatments along with herbicide and control treatments on sites where soil compaction had been relieved by ripping. Composition of vegetation was surveyed prior to treatment in 2014, and annually following treatment. Tree growth and survival were assessed in late summer of 2015, and in Feb. of 2017. Cover of non-native species was initially reduced as a result of the ripping treatment, but recovered rapidly and exceeded 90% cover by the end of the first growing season, while seeded native species have been slow to establish. On average, 30-60% of planted tree seedlings were damaged by deer browsing in the first year, and the probability of browse differed between tree species and between treatments, being less in areas planted with more palatable herbaceous plants. Recent data is being analyzed to determine whether treatments, or browsing, influenced tree growth and survival over the first three years after planting.

0116.04 - Ecological restoration by emulating natural disturbances in boreal forest systems: effects on bird communities

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Many key structures contributing to biodiversity have disappeared from managed forest landscapes. In naturally-dynamic boreal forest systems, natural disturbances like fire, insect outbreaks, windfall and herbivory are important natural processes contributing to high structural complexity. Ecological restoration aiming to emulate these natural disturbances is thought to promote the development of key ecological structures. However, in the boreal biome, research about forest ecosystem restoration is still in its infancy and the responses of many species groups remains to be described. We experimentally tested the short-term (i.e. 4-5 year) effects of two forest restoration treatments ? prescribed burning and artificial gap creation ? on bird assemblages. Detailed censuses of breeding birds were performed using territory mapping in 2015 and 2016 and vegetation measurements were conducted in 2015. Averaged over the two census years, we found 1145 territories of 36 bird species. There was a shift in vegetation structure after prescribed burning, with significantly more dead wood and a less dense understory. Prescribed burning led to clear changes in the structure of the bird assemblages, with higher abundance of long-distance migrants, ground breeders, strong cavity nesters and species preferring early-successional habitats, as well as higher species richness of strong cavity nesters and bark feeders compared to control sites. In contrast, the gap cutting treatment did not show any significant effects on the bird assemblages. Forest managers should be encouraged to use prescribed burning as a restoration tool to provide habitat for bird species adapted to natural disturbances in boreal forest.

0116.05 - Secondary shrublands facilitate the active large-scale restoration of fire-disturbed southern bog forests in North-Patagonia

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Seven years ago we commenced a long-term research project dealing with the ecological restoration of fire-disturbed Southern bog forests previously dominated by the slow-growing, long-lived and vulnerable conifer *Pilgerodendron uviferum* in Chiloé Island, North Patagonia. After 4 years of small-scale restoration experiments, we developed a mixed passive-active restoration approach, that took into account the spatial pattern of the species. A pilot experience of this approach was experimentally applied during winter 2014 at a large-scale of 30 ha, within a matrix of burned bog forests previously dominated by this conifer.

fer. Since dense secondary shrublands considerably hampered the planting process, it was a relevant question whether these shrublands should be retained, or removed before planting. In order to determine the effect of secondary shrublands on the early performance of *P. uviferum* cluster plantings, two treatments: a) shrubland removal, and b) shrubland retention, were randomly assigned to 30 cluster plantations. Our results show that after 3 years of growth, seedlings established beneath retained shrublands showed significantly lower physiological stress (F_v/F_m), and therefore higher height growth, higher vitality, lower browsing rates, and lower frost damage, than seedlings established after shrubland removal. However, seedling mortality -which was surprisingly low (~2%) - showed no significant difference between treatments. These results support, for the first time at larger scales that this species can tolerate extreme wet conditions, yet suffer from stress when grown in the open. In this context, the retention of secondary shrublands facilitates the early performance of *P. uviferum*, by promoting better microsite conditions.

0117 Restoration planning: setting priorities

0117.01 - Restoring forests for biodiversity and ecosystem services: a spatial multicriteria approach to identify priority areas

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Forest restoration can play an increasingly important role in enhancing biodiversity and ecosystem services, as 0.6% of the world's forest is lost annually. In this study, we propose a spatially-explicit model to identify priority areas for forest restoration for maintaining and enhancing biodiversity, and the provision of ecosystem services. We used a multicriteria analysis to assess the ecological suitability to and socioeconomic feasibility of forest restoration. The method was structured into four main steps aimed at: (i) defining potential areas for restoration in deforested lands and degraded forest; (ii) assessing and mapping the suitability of restoration based on ecological criteria (namely biodiversity, water provision, and erosion regulation); (iii) assessing and mapping the feasibility of restoration based on socioeconomic criteria (namely accessibility, pressure on forest, and land tenure); and (iv) combining suitability and feasibility maps to identify priority areas. The methodology was applied to a case study in Chilean temperate forests. Forest degradation was defined based on empirical evidence at landscape scale of alterations in forest regeneration by human-induced disturbances. Restoration priorities were identified as the areas that consistently show the highest suitability and feasibility values under different scenarios, (e.g. biodiversity oriented). While the results presented here reflect the characteristics of a specific study area, the methodology can be easily adapted to different contexts and goals, or modified to incorporate the opinion of stakeholders and experts. This method will allow practitioners understanding where to restore according to ecological variables, and define the feasibility of restoration activities in the medium/long term.

0117.02 - A multi-scale framework for investigating the abilities of ecosystems restoration

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The present proposal embraces a multi-scale approach (a conceptual model) to drive restoration decisions. Four projects gave support to the framework developed: Project 1 (large scale) is assessing areas according to the potential of spontaneous (passive restoration) or assisted natural regeneration. Project 2 (medium scale) aims to test the effectiveness of two nucleation techniques in urban parks as a tool for increasing the local biodiversity. Through the project 3 (also of medium scale) we are testing suitable tools in terms of landscaping and ecological indicators, for improving the local environmental quality in stretches of concrete-lined rivers in urban areas. In the project 4 (small scale) the objective is testing bio-blankets constructed with grass fibers, with incorporated seeds, as a tool to control the erosive process and/or to recover the degraded soil and/or control the expansion of plant invaders. We have tested our approach through a study case in Sorocaba, SP, Brazil. For the landscape-level analysis, the user of the model is asked to have a digital, georeferenced land cover map. Next, the user should follow the instructions described. After identifying areas suitable for passive restoration and areas where assisted natural regeneration can be successful, the user might opt by a set of middle- and site-specific alternatives of restoration aiming to reestablish landscape connectivity, revitalizing concrete-lined urban rivers, controlling erosion and plant invaders, aiming to increment the resilience of the ecosystems.

0117.03 - Using numerical simulations to improve planning, efficiency, and management of forest restoration projects

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Restoring forests by active intervention is an expensive practice. As the long-term dynamics of such systems present many layers of unpredictability, species pool and planting configuration choices are often based only on expertise opinion, a worrying scenario for stakeholders. Forest growth simulators (FGS) offer positive perspectives on how to attenuate this problem. With virtual and realistic scenarios, multi-agent interaction models can provide insightful glimpses about how restoration projects can play out in the long run. Species diversity, population dynamics, biomass among other variables can be assessed at low cost and short time, supporting managers with objective information. To test the potential of long-term prognosis on such basis, we used an empirical FGS (BWINPro), which uses assumptions and parameters based on experimental data, and growth, competition, regeneration rates, and spatial patterns are explicitly addressed. The simulation experiment considers two very similar initial configurations, C01 and C02, that differ only by the presence/absence of one invasive species (C01:26 species, and C02:25 species). According to results, the seemingly insignificant differences between the two initial configurations produced surprisingly different outcomes, where C02 showed higher and significant diversity than C01 (C01: R = 6 spp, H = 0,2; C02: R = 9spp, H = 0,6). Concluding, the use of numerical simulations show great potential to improve the efficiency of restoration practices and techniques, allowing the detection of non-trivial aspects of ecosystem development. We call attention for the use of these tools in restoration planning and the necessity for their improvement and adaptation to different scenarios.

0117.04 - Ecological characteristics of large severely degraded areas in Iceland.

OLAFUR ARNALDS

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Icelandic ecosystems have underwent a large scale degradation and many have collapsed in the past 1200 years since settlement of the island. The original pristine systems were characterized by fertile Andosols of high organic content, nutrient status and water holding capacity. Many of these systems were thrust below critical thresholds by land use such as grazing and wood harvesting, leading to massive destruction in wake of repeated cold spells, volcanic eruptions and other disturbances. Much of remaining vegetated systems are in a degraded state with reduced ecosystem functioning. Massive erosion has removed the original fertile soils from vast areas, leaving infertile barren surfaces behind: desertification in high latitude moist environment. The severely degraded systems are characterized by lack of vegetation cover and energy input (photosynthesis), low organic content and nutrient state. Many of the surfaces have become 'sandified', creating sandy surfaces of limited water holding capacity and extreme instability, rendering these surfaces difficult to restore. Erosion has been surveyed in all of the country together with vegetation mapping and soil identification of the main vegetation classes and ecotypes. Such data can be used to categorize the severity of the degradation and the condition of the land in relation to fully functional or pristine systems. Such assessment is important for developing ecological restoration policies and strategies for the severely degraded areas.

0117.05 - Evaluation of restoration priority on streams in Singapore

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Stream mapping, hydrological characteristics and biodiversity baseline have been carried out for more than 40 natural earth streams in Singapore, and most of which are providing significant ecological function and services supporting a wide range of native fauna and flora through their in-stream habitats, riparian and stream corridor vegetation. Most of these streams are experiencing ecological stresses caused by both natural and human induced disturbances. Resilient, mitigation and intervention measures are required to address the current problems so that biodiversity conservation and ecosystem services of streams can be sustained in the long term. However, available resources (funding, manpower) are always limited as compared to the work required, thus prioritization of streams and become one of the most important steps in restoration and conservation planning. In this study, stream data collected over the last 5 years were used to formulate a scoring method to evaluate the restoration

priority with emphasis on significance of stream in local and global biodiversity conservation, taking into account of endemic, locally endangered, and globally threatened species that the stream is supporting; together with assessment of ecological and hydrological degradations that the stream is experiencing, taking into account of the extreme scenarios of climate change effects. Potential threats of urban development could also be a major consideration. Contribution of such evaluation results to the development of a restoration strategy and action plan for biodiversity conservation of Singapore streams will also be discussed.

0117.06 - Ecological restoration of the Inter-andean Tropical dry forest in Colombia as a compensation strategy associated with an Hydroelectrical project

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In the Inter-andean Valleys of Magdalena River in the department of Huila (Colombia) was constructed “El Quimbo” Hydroelectrical project. The governmental authority defined as biotic compensation measure for this project a process of ecological restoration over 11,079 hectares of Tropical Dry Forest that must be developed over the next 20 years. As an approach to the 11,079 hectares restoration process, currently it is being developed since April 2014 a Restoration pilot plan in 140 hectares in order to determine the most successful restoration strategies in terms of cost – benefit that can be replicated over the 11,079 hectares, the region and the dry forests of the country. This was a technical challenge because in the country there was not much knowledge related to the process of restoration in tropical dry forest. For this reason all the information obtained has been important not only to know the dynamics of the ecosystem but also the administrative, operational and costs aspects that the restoration entails. The techniques, methodological processes and results have been shared and taught to the community through a Tropical Dry Forest Research Center. The main advances of the pilot plan are: 1) Prioritization of 140 hectares for the implementation of pilot plots through multi-criteria analysis; 2) biotic and physical characterization, 3) definition of various designs of restoration strategies over shrublands, grasslands and forests according the restoration objectives and biophysical conditions analyzed, 4) propagation of 114,828 seedlings of 62 Native species of tropical dry forest, 6) Establishment of restoration strategies, 7) Monitoring strategies with verifiable and quantifiable goals in the short, medium and long term, 8) communication strategies for local and regional community and 7) research works associated with the restoration plan.

S118 Revegetation for ecological restoration in the Amazon

Organizer: Myrtle Shock

S118.01 - Experimental reforestation after gold mining in the Peruvian Amazon

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Gold demand has fueled a massive increase in mining activity, some of which is centered in the Amazon basin. Western Amazonian forests of Peru in Madre de Dios are one of the highest biodiversity regions on Earth, and have become an epicenter for mostly illegal gold mining, which have transformed large expanses of virgin rainforest into denuded and mercury-poisoned wastelands. In Madre de Dios, areas degraded by mining are devalued and present severe limitations for agricultural development and for the natural or induced regeneration of the native forest. Despite its acknowledged importance, reforestation has rarely been manipulated experimentally, and the interaction of plant growth with soil degradation and mercury contamination is poorly understood. Therefore, the objectives of this study were to (1) evaluate the level of soil degradation and contamination after mining operations; and (2) assess the initial survivorship and growth of 40 woody species in abandoned mines by using drones. Soil degradation was evaluated by comparing physical and chemical soil properties, as well as mercury contamination, between degraded areas and the nearest undisturbed reference forest. We analyze the outcomes of different planting methods and organic fertilization on the initial survival and growth of the woody species planted. One year after planting, we sampled roots, stems and leaves of the planted species among treatments in order to detect possible contamination with heavy metals. The results of this study could support the design and implementation of land remediation and forest restoration projects on a larger scale.

S118.02 - Can Brazil nut plantation recover soil properties in former pasture lands?

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Soils of livestock pastures are heavily degraded in the Amazon region compared to conditions immediately after deforestation. We hypothesized that income-generating Brazil nut plantations (*Bertholletia excelsa*) and natural succession secondary forests can recover soil properties of these lands. To test this, we sampled two 200-cm soil pits in four vegetation types: pasture (PA), Brazil-nut plantation (BN), secondary Forest (SF) and primary Forest (PF). Soil samples were collected at nine fixed depths to measure bulk density, pH, soil organic carbon (SOC), total nitrogen (TN) and C/N-ratio. The SOC concentration, TN and C/N-ratio did not differ significantly among vegetation types in any soil layer, even if the mean SOC concentrations of BN and SF were between those of PA and PF in the 0-5 cm layer. Bulk densities of PA (1.47 g cm⁻³) and PF (1.11 g cm⁻³) differed significantly in 0-5 cm, while those of BN (1.31 g cm⁻³) and SF (1.34 g cm⁻³) were in between and not significantly different from PA nor PF. pH differed significantly among vegetation types in the 0-5 cm layer, except BN and SF. The highest pH was found in PA (4.7), probably due to alkaline ashes from initial slash-and-burn, and the lowest in PF (3.5). pH was generally higher in PA down to at least 30 cm. The results suggest that SOC and TN were robust to land use changes, while bulk density and pH were more sensitive. BN and SF showed potentials for recovery of soil properties as bulk density and pH.

S118.03 - Particular soil chemical parameter challenges of highly degraded Amazon sites

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Human activities have had negative effects on natural ecosystems in the Amazon. Areas become degraded through logging, ranching, mining, farming, and the development of infrastructure. Activities that remove or disturb vegetation cover also change how the landscape captures and releases precipitation, retains soil, and cycles nutrients. In the early 1970's, a path for the BR-319 highway was opened for 871 km from Manaus to Porto Velho removing vegetation and much of the topsoil, exposing subsoil. Spontaneous vegetation did not regrow on many disturbed sites. The Brazilian National Highway Department contracted the IRI Research Institute to study the problem and develop revegetation options. The average surface soil nutrition was determined for eight roadside stretches between kms 11 and 871 of BR-319. Also, soils from eleven degraded areas were analyzed to characterize their conditions and choose locations for revegetation trials. Six of the roadside stretches had low calcium; seven stretches had low magnesium and boron; and all had low phosphorus, sulfur, manganese, and zinc. Copper and iron were moderate in all stretches. Subsoils from the eleven degraded areas without spontaneous revegetation averaged 4.7 pH, 1 mg•L⁻¹ of available P, and 32 mg•L⁻¹ of exchangeable K. The cation exchange was dominated by aluminum averaging 0.1, 0.06, and 5.2 meq•100ml⁻¹ of calcium, magnesium, and aluminum, respectively. These subsoil attributes along with generally low levels of sulfur, boron, manganese, and zinc explained the lack of vegetation following highway construction.

S118.04 - Early plant establishment and succession under revegetated sites in Amazonas, Brazil

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Amazonian soils and subsoils have been exposed to erosion through construction, extractive industries, and agriculture. Their revegetation can be challenging due to low fertility, heavy rainfall, and repeated disruption. The Amazonian highway BR-319 from Manaus to Porto Velho was opened in 1973. Over much of its length, the construction of the highway exposed subsoil and parent material that failed to support spontaneous vegetation. At the initiative of the Brazilian National Highway Department, native and introduced grasses and legumes were evaluated for their ability to rapidly cover the amended subsoil and persist. Following initial screening of plant species, a replicated trial using 15 grasses and 9 legumes was planted in February 1976 on an acid, infertile site using a strip-plot experimental design with three replicates. The planting received minimal initial fertilization and liming. Richmond finger grass (*Digitaria diversinervis*) provided the most rapid soil cover followed by hilograss (*Paspalum conjugatum*). In contrast legume development was relatively slow. Only tropical kudzu (*Pueraria phaseoloides*) and velvet bean (*Mucuna pruriens*) had rapid growth. *Stylosanthes guianensis* and three other legumes exceeded 20% soil cover by 1y. After 2.5y, 13 grasses and 3 legumes were considered useful for revegetation and after 7.8y, 10 grasses and 3 legumes persisted. At 7.8y *Pueraria phaseoloides* and *Stylosanthes guianensis* contributed to vegetative cover and the *Urochloa* grass species persisted strongly. The native grasses *Paspalum conjugatum* and *Homolepis aturensis* provided rapid early groundcover, giving way to other species over time.

S118.05 - Plant succession 36 years following revegetation on degraded sites in Amazonas, Brazil

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In February 1976 a replicated trial using 15 grasses and 9 legumes was planted on an acid, infertile Amazon site using a strip-plot experimental design with three replicates. The planting was minimally fertilized and limed in 1976 and received no management after 1978. Only three of the species planted persisted at the site in 2013, *Urochloa brizantha*, *Urochloa humidicola* and *Stylosanthes guianensis*. In 2013 the plant species present in the revegetated site without *Urochloa brizantha*, the revegetated areas of the site with *Urochloa brizantha*, the adjoining areas without vegetation, and the adjacent secondary forest were identified. The composition of the vegetation in each of these four areas was evaluated. The area without revegetation was mostly bare,

with 0.2 plants•m⁻² and three species present. Plant composition samples from the secondary forest, revegetated area, and area revegetated where *Urochloa brizantha* was present had 4.8, 78.6, and 57.0 plants•m⁻², respectively. The corresponding vegetation inventories had 56, 42, and 15 species, respectively. Where *Urochloa brizantha* was present, it dominated the groundcover with 44.6 plants•m⁻² and 78.2% of the plants present. In the revegetated area without *Urochloa brizantha*, 8.92% of the plants present and 7.1% of the species present were also found in the adjacent secondary forest, principally *Vismia japurensis*. The 1976 revegetation and its initial selection of species planted led to a diverse successional plant community after 36 years, with the exception of the places planted to *Urochloa brizantha*.

S118.06 - Soil formation under revegetated sites along the BR-319 Highway, Amazonas, Brazil

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The exposure of subsoil by soil disruption results in areas of low fertility. The immediate challenges to restoration in the Amazon are the reduction of erosion and recuperation of surface soil horizons. Revegetation trials were conducted between 1975 and 1978 along the Amazonian Highway BR-319. The highway construction exposed subsoil and parent material. Grasses and legumes were planted for revegetation in 1976 along BR 319 near km 176, a reach that supported very little spontaneous vegetation. The revegetation received modest fertilization and liming once at planting. The revegetation sites were adjacent to additional denuded areas and vigorous secondary forest. Soil formed in the revegetated parcels during the subsequent 36ys as vegetation successional dynamics led to low scrub. In 2013 soil samples were collected at 0-25, 25-75, 75-200 and 200-400mm depth in the denuded areas not revegetated, in the revegetated areas (both dominated by grass and occupied by diverse plant succession), and in the secondary forest and subjected to analytical tests. Soil organic matter in the surface 25 mm layer averaged 2, 78, 77, and 76g•kg⁻¹ in the unplanted, grass, mixed revegetation, and secondary forest areas respectively. The corresponding values for the next layer were 2, 16, 25, and 27g•kg⁻¹. Residual soil nutrients from fertilizer and lime added at plant establishment were present for P, K, Ca, Mg, Fe, Zn, Cu, and Mn. Soil properties were transformed by the soil correction and revegetation. The development of soil over 36y shows that the progression of degradation can be reversed.

0120 Community engagement in ecological restoration: motivations and practice in South America

0120.01 - Pilot experience of ecological restoration in an area of *Pinus patula* in the Regional Natural Park Páramo de Rabanal, Sacamá – Boyacá

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One of the main strategic ecosystems in Colombia are paramos, due to provides a wide range of ecosystem services, like regulation and supplying of water resource. However, the natural plant cover of this ecosystems has been replaced by plantations of exotic species destroying and transforming the natural dynamics, structure and composition. This event occurs in the paramo Rabanal (Cundinamarca and Boyaca, Colombia), which has been disturbed by a plantation of *Pinus patula* and forest harvesting at different scales of time and space. In this way, were identified some important stressing and limiting factors, as: persistent forest waste, strong winds, high solar radiation and erosion by superficial runoff. Owing to that, was generated some strategies of active restoration, like the selection and planting of key species such as *Lupinus bogotensis* and *Baccharis bogotensis*, disposal of waste, implementation of amendments and use of artificial burrows as encourages of dispersal processes. Also, was proposed a community-based monitoring with the purpose of generate sense of belonging and knowledge through a training process that allows them to carry out the respective measurements. The principal objective of this pilot project is to generate knowledge about process of ecology restoration in affected areas by forest plantations and replicate the results at national and international scales.

0120.02 - Contributions to environmental governance from the participatory ecological restoration

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The concept of governance refers to the joint action of the state, companies and civil society in the formulation and execution of public policies for the purpose of achieving a common good. Working together strengthens the role of each of them, the civil community as connoisseurs and seekers of its territory; the company, as executor and financier and the state as the regulator of this type of processes, in an articulated way. Thus, the role of governance in ecological restoration is conceived as the joint action of these three sectors for the restoration and recovery of degraded areas. From a socio-ecological approach, the well-being of many communities depends on the state of ecosystems and their services; the access and use of services may be mediated by conflict. Therefore, there must be local governance system capable of collaborating and participating in the recovery of disturbed areas, conflicts and the benefits of recovery. An analysis of five cases of participatory ecological restoration in Colombia, illustrates both the benefits and limitations of the bridges that are being developed between restoration scientists and communities to improve participation and governance, as well as socio-environmental conflict situations and its impact on restoration processes. A model is proposed that strengthens the practice of participatory ecological restoration, increasing the possibility of success of the projects and improve governance and sustainability.

0120.03 - Ecological restoration of strategic ecosystems in the Ariguaní River basin (Algarrobo and Fundación, Magdalena)

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The tropical dry forest ecosystem in Colombia has gone through a long period of disturbance, principally by land-use changes due to the natural vocations of the land and the actual human uses. Consequently, the vegetation cover was transformed, generating changes in the hydrological cycles and giving rise to erosive processes and floods that affect communities located on the affected area. For instance, in the Ariguaní river basin, specifically on Chimila

wetland (town of Algarrobo, Magdalena, Colombia) the dry forest ecosystem has been changed through time and space, generating different social and ecological issues, making it vulnerable to climate change, principally, because of overgrazing and single-crop of oil palm and cotton, over the buffer zone of the wetland. This information was corroborated by a comparative multitemporal analysis between 1953 and 2016. Based on these problems, an ecological restoration strategy was proposed, based on the rehabilitation of native vegetation by planting shrubs and tree coverages with properties of tolerance and water regulation and used by the community. This proposal was focused on ecosystems services of Chimila wetland, water sources, social needs and interest, and principally, on the ecological restoration of natural tropical dry forest.

0120.04 - Socioeconomic impacts of the Ecuadorian Forest Restoration National Plan

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Environmental restoration actions widely depend on the active participation of local communities. It is therefore essential to understand what motivates farmers in ecosystems restoration. The present study is part of ReFloramaz, a learning-practice network of practitioners and researchers on forest restoration by smallholders in the Eastern Amazon. This pilot study aimed at analysing the motivations and barriers of family farmers to comply with forest legislation and restore their areas. The study area is the municipality of Paragominas, Pará. We selected two traditional communities along Capim River (Nazaré and São Sebastião) that are involved in the “Pará Florestal Program” (PFP), which aims at restoration through Agroforestry Systems. A semi-open questionnaire was applied to 34 farmers (aprox. 25% of households) in order to understand the level of knowledge and acceptance of environmental laws, the perceptions about natural resources, and motivations and barriers for restoration. By combining qualitative analyses and Multiple Correspondence Analysis, we assess the relationship among farmers’ characteristics and their motivations. Farmers with rural environmental registration (CAR) had more knowledge about the laws, but were not necessarily more compliant. The willingness to restore forests was not only associated with participants in the PFP. However, PFP participants seemed to be more aware of local biodiversity and saw less barriers to forest restoration. A lower interest in restoration was associated with younger farmers (<45 years), non-illiterate and with smaller families. Our results highlight the relevance in considering a range of smallholder’s characteristics and attitudes to ensure success in forest restoration actions

0120.05 - Smallholders’ motivations to restore forests in Eastern Brazilian Amazon

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Environmental restoration actions widely depend on the active participation of local communities. It is therefore essential to understand what motivates farmers in ecosystems restoration. The present study is part of ReFloramaz, a learning-practice network of practitioners and researchers on forest restoration by smallholders in the Eastern Amazon. This pilot study aimed at analysing the motivations and barriers of family farmers to comply with forest legislation and restore their areas. The study area is the municipality of Paragominas, Pará. We selected two traditional communities along Capim River (Nazaré and São Sebastião) that are involved in the “Pará Florestal Program” (PFP), which aims at restoration through Agroforestry Systems. A semi-open questionnaire was applied to 34 farmers (aprox. 25% of households) in order to understand the level of knowledge and acceptance of environmental laws, the perceptions about natural resources, and motivations and barriers for restoration. By combining qualitative analyses and Multiple Correspondence Analysis, we assess the relationship among farmers’ characteristics and their motivations. Farmers with rural environmental registration (CAR) had more knowledge about the laws, but were not necessarily more compliant. The willingness to restore forests was not only associated with participants in the PFP. However, PFP participants seemed to be more aware of local biodiversity and saw less barriers to forest restoration. A lower interest in restoration was associated with younger farmers (<45 years), non-illiterate and with smaller families. Our results highlight the relevance in considering a range of smallholder’s characteristics and attitudes to ensure success in forest restoration actions

ABSTRACTS / POSTER PRESENTATION

Agroecosystems/agroforestry

T16-P01 - Potential of home gardens in the restoration of protected areas: aspects of forest legislation

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Laws and resolutions regulate human activities and should set criteria for small farms to restore degraded areas, and also implementation of agroforestry plantations in their areas of permanent preservation (APP) and legal reserve (RL). This study aims to analyze the legislation to identify theories and legal concepts that address and enable the potential for adoption of home gardens as a method for the APP and RL restoration. Therefore, we analyzed the Forest Law nº 12,651 /2012, and the São Paulo state resolutions SMA nº 44/2008 and SMA nº 32/2014 considering a set of concepts, attributes, and references applied to the legislation based on ecosystem services theory. In assessing the legal resolutions related with the theory of environmental services, we analyzed the concepts towards the production, regulation and support. The attributes relating to cultural issues were not explicit in any of the legislations. The analysis of the other concepts highlighted the potentiality and relevance of the adoption of home gardens in the provision of environmental services in legal reserve, and preservation areas, especially if legal frameworks incorporate cultural issues.

T16-P02 - Agroforestry systems as strategy to improve soil quality in degraded land: promoting soil fauna and ecosystem services

TATIANI MARIA PECH; GUILHERME DIEGO FOCKINK; MAYRINE SILVA; ALEXANDRE SIMINSKI; KARINE LOUISE DOS SANTOS; JULIA CARINA NIEMEYER

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Agroforestry systems are land management strategy where trees, shrubs, field crops and/or animal production are integrated on the same area. These integrated systems have the advantage of being productive, protective, and other services provides by its local biodiversity. Among these species, soil invertebrates are sensitive to changes in plant cover, management regime, and microclimate, being useful organisms to indicate soil quality improvement. In the present work, macrofaunal was sampled by Tropical Soil Biology and Fertility (TSBF) methodology in three different compositions of agroforestry (trees + field crops, trees + *Ilex paraguayensis*, trees + native fruit trees), implemented in a degraded site after a *Pinus taeda* plantation was removed. Two neighbouring sites were used in comparisons: a pinus plantation and a natural ecological succession without management. Macrofauna species were collected by pitfall traps, earthworms by monoliths, and enchytraeids by wet extraction from samples of soil. Feeding activity of soil fauna was determined using bait lamina test, exposed by 40 days in soil. Results indicated improvement of soil quality indicated by higher feeding activity of soil fauna in agroforestry systems, especially when species composition included field crops. Agroforestry promoted higher abundance of earthworms and enchytraeids in comparison to pinus plantation and with the ecological succession without management. Agroforestry systems improved soil fauna abundance and activity when used to manage degraded land, and consequently promoting ecosystem services carried out by these species. Results showed a different contribution of tree species to improve soil fauna activity, which should be further investigated.

T16-P03 - Agroforestry system as strategy for forest restoration in small farms in southern Brazil

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Agroforestry systems are an important strategy for restoration degraded areas in areas of tropical climate, a fact justified by the climatic and economic elements characteristic of these regions. These strategies can offer the restoration of ecosystem and socioeconomic services, especially when the focus is on non-timber forest products. In this scenario, the objective of the research was to identify native plant species adapted to the conditions of the Mixed Ombrophilous Forest (an ecosystem from Atlantic Rainforest in Southern Brazil), with ecological, social and economic potential, in order to form an agroforestry system model for environmental restoration in agricultural properties. The study was conducted in the Mixed Ombrophilous Forest ecosystem in the region of Santa Catarina state, from July of 2016 until March of 2017. Data collection used the intentional sampling methodology to highlight farmers with knowledge related to native plants of the region. Ten ethnobotanical surveys were carried out with farmers in five municipalities (Curitibanos, Frei Rogério, Santa Cecília, Ponte Alta do Norte, São Cristovão do Sul) of Santa Catarina State. The analysis evaluated the degree of importance of the species, based on the informants consensus. It were identified 146 ethnospecies, being 85 trees, 26 shrubs and 35 herbaceous. According to the local knowledge the five species that present the best potential for agroforestry systems in Mixed Ombrophilous Forest areas have both cultural and economic potential, highlighting the potential of agroforestry systems to conserve natural resources and thereby to support agricultural development by connecting environmental conservation with income for farmers.

Communicating restoration science: outreaching, extension, training

T04-P01 - How to be an effective advocate for plants: lessons from the “botany bill” in the U.S.

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“Plant Blindness” is a documented phenomenon in people; it is the tendency of humans not to notice or appreciate the importance of plants. This has manifested in less funding and less protection for plants than for animals in the U.S.; e.g. threatened and endangered plants receive less than 4% of the federal funding for species recovery despite comprising more than 60% of listed T&E species. Our assessment of botanical capacity in the U.S. also found that botanists are underrepresented in many sectors, including land-management agencies. For example, in the U.S. Geological Survey, which provides research to guide management of nearly 400 million acres of public lands, we found that wildlife scientists outnumber botanists by over 20 to 1 in an assessment of the science centers in the western U.S. Training the next generation of botanists is also in jeopardy. In 1988, 72% of the top 50 funded universities in the U.S. offered advanced degree programs in botany. Today, more than half of these universities have eliminated their botany programs and many, if not all, related courses.

This assessment led to an organized effort by the Plant Conservation Alliance Non-Federal Cooperators to advocate for support of increasing botanical capacity, native plant programs, and restoration. We discuss how to develop and deliver a pro-plant message to decision makers, using the example of the “botany bill,” recently introduced legislation in the U.S. which if enacted will support plant scientists, plant funding, and the use of native plants on federal lands.

T04-P02 - Teaching Ecological Restoration: An analysis of Post-Graduate courses in Brazil

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Several ambitious restoration targets have been announced to repair degraded ecosystems in Brazil (e.g 21 million hectares of legal compliance). Therefore, the provision of scientific knowledge and skilled labor are fundamental to achieve restoration success in the medium and long terms. In this study, we described the profile of restoration ecology courses and its consequences for science and practices. Data collection took place in the second semester of 2015 assessing the contents of each course. We surveyed 272 post-graduate programs, comprising six specific areas (forestry, soil, botany, environmental engineering, ecology and environmental science). After that, we analyze all selected courses in terms of location, approach (economic, social and legal) and restoration techniques. Our results showed that only 27% of post-graduate programs analyzed offer restoration ecology courses. Geographical distribution indicates that 49% of the courses are in the southeast region. Other regions covered by non-forest ecosystems, such as Pampa, Caatinga and Cerrado, were poorly represented. Legal aspects were considered in 51% of the courses, whereas social and economic approaches were considered in only 2.7% and 11%, respectively. Tree plantations (85%) and nucleation (68%) were the most cited techniques of active restoration and passive restoration was mentioned in 63% of courses. Our findings highlight the necessity to increase post-graduate courses in areas of non-forest ecosystems, especially because there are knowledge gaps about how to restore these communities. Incorporating economic and social approaches is highly recommended because of the importance of these attributes to reach large-scale restoration success.

T04-P03 - Training of ‘multipliers’ as a tool to scale the native vegetation restoration in Brazil

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With the ratification of the Paris Agreement by Brazil in September 2016, the country proposed as a goal a possible reduction of 43% of emissions by 2030; one of the actions to achieve this goal is the restoration of 12 million hectares of forests. This is a big challenge given the unstructured restoration chain in country and lack of professionals trained in the different links of the chain. Having knowledge multipliers technically qualified is essential to meet the regularization of rural properties demand and it is also an important tool to scale up restoration allowing the country to reach committed objectives, generating local development, new jobs, income and conservation results. Through different projects, The Nature Conservancy develops training programs and materials related to restoration of native vegetation to fill the bottlenecks in technical knowledge. Almost 1,000 people were trained and important lessons learned were identified, such as the need for specific teaching materials to different social and environmental scenarios; practical application of field techniques; stimulating knowledge exchange; partnerships with municipal, state and federal government; encouraging the monitoring of field actions and the involvement of stakeholders in the strategic planning process. The main results are Demonstrative Units installed in more than seven states of the country, restoration professionals and knowledge multipliers trained, promotion of seed collection groups, seedlings producers, greater local autonomy in regularization and inspection of properties with higher quality and better cost-benefit, and areas in restoration process.

T04-P04 - Restoring educational approaches: Games for ecological restoration learning

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Education for ecological restoration has focused on post-secondary or tertiary institutions courses with technical and scientific frameworks. However, there is a huge lack of learning tool affordable and accessible to multilateral actors, such as schools and local communities. For this reason, we developed games as educational instruments based on local and technical knowledge of the Xingu Seeds Network. This Network initiative is a successful seed supplier in Brazil which have produced 175 tons native seeds over 10 years in the Southeast Brazilian Amazon. Our aim is to assess the creation process and outcomes of these games when public interacts within it. Thus, we first organized meetings with technical staffs to identify relevant restoration experiences. And then, we obtained local knowledge from seed collectors (narratives, myths, and perceptions) about multiple aspects of restoration. Thus, all these data were transcribed and categorized to design two games: (i) card game to explore native trees phenology; (ii) board game about why, what, where, and how to restore degraded lands. Finally, we tested these in three workshops to get feedbacks from young people (n= 35), environmental and social specialists (n = 10), and seed collectors (n= 60). In general, stakeholders responded positively to these games to learn and exchange knowledge in groups. These tools promoted an entertainment context for players integrates experiences with technical information. The connection between an individual outcome (harvest natural resources) with a collective achievement (cooperation for restoration) was considered a key element. Therefore, games can support restoration knowledge exchanges among multi-stakeholders.

T04-P05 - Participatory Demonstration Units – a methodology for rural technical assistance and management of agroforestry systems in the São Félix do Xingu municipality in Pará state, Brazil

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Command and control mechanisms have not been efficient in preventing tropical forest degradation and deforestation nor have they helped increase forest restoration. The Nature Conservancy (TNC) and partners such as the Cocoa Planning Executive Commission (Ceplac), the World Agroforestry Center (ICRAF) and the Brazilian Agricultural Research Corporation (Embrapa) have been working on the development and implementation of Agroforestry Systems (AFS) and restoration models that can bring economic

gains to rural producers. However, the implementation of efficient technical assistance methodologies is needed to gain scale in restored areas. The Conservancy created the Participatory Demonstration Unit (PDU) model to expand cocoa AFS in São Felix do Xingu. The PDU consists of an area inside a rural property where there is cocoa AFS and where training and good technical practices are applied with the participation of local rural technicians and farmers who live in the surrounding areas.

The objective of the PDU methodology is to engage the largest number of farmers and technicians possible and provide training on AFS good practices. Using the PDU model has allowed us to assist an average of 30 farmers per training day. Currently, the project has three PDUs established in smallholder properties with an average area of four hectares each. PDU units have been a key strategy to optimize restoration efforts in the region. The Conservancy believes they are essential to achieving the goals of reaching 1,000 families by 2020 and 5,000 hectares of cocoa agroforestry systems and forest restoration in smallholders' farms.

T04-P06 - Connecting economy and ecology through landscape restoration

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Healthy ecosystems are the basis of our life and economy. Their degradation poses a serious threat to our future as is clear from the UN Sustainable Development Goals (SDGs) that frame the international agenda and policies until 2030. Reversing land degradation and restoring landscapes are one of the key components of achieving the SDGs. Outside the community of restorationists and land managers there is a lack of awareness on the functioning of ecosystems and the benefits they provide. To build such awareness among the business community involved in land use and management, the partnership of the European Network for the Advancement of Business and Landscapes Education (ENABLE) was established. The main goal of ENABLE is to develop education platform and material on integrated landscape management based on sustainable business models. The first output of the partnership is a seven week massive open online course (MOOC), launched in spring 2017, about the basic and indispensable knowledge on the interconnectedness of economy and ecology. The MOOC is directed at business students although open to all without any cost. The aim of the MOOC is to raise awareness of the problem of landscape degradation around the globe, and the ways in which businesses can be a part of the solution by creating business-driven landscape restoration initiatives. The partners in the ENABLE partnership are Erasmus University Rotterdam, Commonland, Spanish National Research Council, Estoril Global and UN University Land Restoration Training Programme.

T04-P07 - SER Certification program for ecological restoration practitioners

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Over the last several decades, the relatively new field of ecological restoration has rapidly grown, both in number of projects and in number of practitioners. However, professional standards for practitioners are minimal at best, resulting in inconsistent project quality. As one way of addressing this problem the Society for Ecological Restoration (SER) recently launched a new certified ecological restoration practitioner (CERP) program to create a high professional standard for practitioners throughout the world. Certification is based on a combination of knowledge and experience, and also requires adherence to the SER code of ethics and an understanding of SER's foundational documents. By promoting practitioner standards, SER hopes to improve ecological restoration and the associated benefits on the ground. Certification will also have numerous other benefits: 1) individuals can improve their professional status through formal recognition of their training and experience, 2) academic institutions with ecological restoration degree programs can use the knowledge requirements to evaluate curricula so that graduates will have the core competencies specific to the field; and 3) employers, agencies, organizations, and the general public will benefit by easily being able to identify those practitioners who meet the high standard set by SER. You can find out more about the program benefits and requirements at <http://www.ser.org/page/certification>.

T04-P08 - The role of civil society in ecological restoration: Campaign “Sembremos Agua” in Guanacaste a case of success in Costa Rica

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Ecological restoration plans in Costa Rica have as main challenges to overcome the budget for its implementation and scientific monitoring; and in particular, to ensure that civil society is aware of its ecological footprint and of its responsibility to promote restoration as a strategy for sustainable development. In this sense, within these deficiencies, Huella Verde-UNED project identified an opportunity to bring people closer to ecological restoration and, in turn, obtain financing in order to restore ecosystems vulnerable to climate change, where drought affects natural and anthropized ecosystems significantly. Through the Campaign “Sembremos Agua” in Guanacaste, Costa Rica State Distance University, the Ministry of Environment and Energy and the Chamber of Tourism for Guanacaste developed a process of education and environmental awareness for a year, by using materials with scientific content that was visually attractive and in a language easy to understand for the whole audience. In its second stage, through national television and social networks, the Campaign broadcasted inclusive videos with visual gestural communication (CVG-LESCO) for the understanding of deaf individuals and starred a recognized national athlete. These videos encourage the economic donation by sending text messages through cell phones (broadcasting messages). Donations finance germplasm banks in which native plants are grown to be used in ecological restoration plans in the province of Guanacaste.

T04-P09 - A network of collaborators to support restoration of ecosystems degraded by alien invasive species

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Alien invasive species (AIS) pose a global threat, considered by the International Convention on Biological Diversity (CBD) as the leading cause of biodiversity loss in Conservation Units (UC). The Environmental Institute of Paraná (IAP), UC manager, found that all protected areas (91,394 ha) contained alien species. In 2009, it launched the Paraná State Program for AIS, with the objective of preventing the introduction of species with invasive potential and taking actions to control and/or eradicate those that are in the state. Eradication and control actions were implemented in 15,253 ha (17% of the UC total area) and these restored areas are being reinserted into the conservation process. To face the demands it was created the Network of Collaborators to the Paraná State Program for Alien Invasive Species (RedEEI), with specialists from different areas. The RedEEI seeks to engage people who perceive AIS as a problem that deserves attention and diverse actions. These people register voluntarily, indicating activities that have affinity and that they can develop locally. RedEEI aims to expand the scope of practical actions in the area of AIS, involving information, planning and development of strategies for prevention, eradication and control. RedEEI has 68 collaborators and had generated products to support the restoration of ecosystems degraded by AIS and information dissemination, to enhance actions from different society segments. Important results were the engagement and willingness of experts to collaborate on a voluntary basis, effectively contributing to the restoration of ecosystems degraded by AIS.

Community engagement in ecological restoration

T05-P01 - Guidelines to a proposal of ecological restoration for high mountain Andes forests degraded by human use in San Miguel – National Park Tunari (Cochabamba, Bolivia)

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San Miguel is a Quechua community inside the National Park Tunari (PNT), Cochabamba, Bolivia. There are remnants of the *Polylepis subtusalbida* native forest (Kewiña). This formation has been affected by human use and replaced by *Pinus radiata* and *Eucalyptus globulus*, exotic species well known to be harmful to the ecosystem. Therefore, in this work we propose the recovery of the *Polylepis* forest in areas currently occupied by timber plantations. The good conservation condition of the *Polylepis* forest is defined by the presence of the bird *Oreomanes fraseri*. Based on interviews with the community, we characterized the critical factors of the forest degradation. We elaborated a talking map of presence and abundance of the bioindicator bird, delimited a surface of 50 ha around San Miguel, in which all the vegetation formations were identified, and found that nearly 50% of the area are crops and households, the rest are fragments of *Polylepis* forest, mixed forest with plantations, plantations and pasturelands. We defined the reference area and the most adequate area for starting the replacement of plantations with *Polylepis*. Interviews revealed that the main impediments for the native forest conservation and the services it provides are its displacement by exotic species, the expansion of croplands and forest fires. Additionally, poverty is making people migrate to the city, increase agricultural pressure over soil and wanting to expand woodlands for logging. We propose the introduction of alternative economic activities, environmental education and the elimination of exotic species so the native forest can slowly recover itself.

T05-P02 - Initiatives involving the use of bamboos: The importance of species and socialecological context to achieve effective ecological restoration

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A bamboo-specific national policy was created in 2011 (Law number 12.484) providing an official set for initiatives from production, governmental, research and development sectors to implement a production chain in Brazil, gifted with vast areas seen as eligible for cultivation and management. These include forests with bamboo in the Amazon and sites to be restored and managed for economic purposes (especially legal reserves). Brazil holds approximately 30% of worldwide bamboo species (258 native species from 35 genera). However, the use of mostly exotic bamboos has been promoted by formal and informal restoration projects, despite the lack of knowledge about the impacts. To understand the broad management of Brazilian native bamboos, we listed and characterized initiatives related to their use and conservation from 2014 to 2016 through: i. Survey on scientific literature, digital media and snowball sampling; and ii. Interviews with representatives of 72 initiatives from different sectors in national and local levels (in four municipalities of Acre State, in 2016). We listed 14 issues directly related to ecological restoration and biodiversity conservation, such as: general treatment as “bamboos”, lack of knowledge and technical expertise on native bamboos, substitution of native by exotic species, dominance and invasibility of certain species, scarcity and vulnerability of native species and unclear environmental legislation. Initiatives on bamboos from different sectors should consider those issues, in part significantly solved through basic comprehension of bamboo species and socialecological contexts, to better articulate goals aiming at the integration between development and ecological restoration.

T05-P03 - Enhancement of tropical tree diversity by a 25-years forest restoration in a small Brazilian property

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Forest reforestation mainly in small and medium properties is an important practice that contributes to avoid rural exodus and improvements. Our objective was to evaluate the biological diversity of trees of a 25 years-forest reforestation area and of a forest remnant of Montane Seasonal Semidecidual forest in the Serra da Mantiqueira region, Minas Gerais state, Brazil. Three plots of 4 x 25 m were allocated at each area. We sampled every individual of at least 1.3 m high and identifying its species. To analyze the effects of the sample size we evaluated whether the abundance varies between areas by applying Mann-Whitney U test. As species diversity descriptors, we calculated richness (S = number of species in the samples), Shannon-Wiener diversity, Pielou evenness, and Sorensen similarity index. We compared diversity of forest restoration and forest remnant by using the t-test. The abundance did not vary between areas ($U= 2$, $p= 0.40$). Forest restoration presented 30 species, 2.99 for diversity and 0.88 for evenness, and forest remnant presented 37 species, 3.08 for diversity, and 0.85 for evenness. We recorded nine species in common at the two areas, 28 exclusive species in the forest remnant and 21 exclusive species in the forest restoration, in which only one species is exotic. The areas did not show differences for abundance and diversity. Despite the diversity did not vary between forest restoration and forest remnant, it is interesting to highlight the occurrence of exclusive species in each area. Those species are responsible for enriching the plant community of the property. Our results indicate that restoration actions, implemented by landowners, focused on enhancing biodiversity help in the conservation of species of the region.

T05-P04 - Ecosystem services in ecological restoration: Perception of urban communities

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Ecosystem services establish clear connections between conservation and human well-being, provide approaches that lead to ecological restoration, stimulate funding and legislation for the practice of ecological restoration, and can induce the sustainable use of forest resources. This study aimed to identify the perception of urban communities and the local workforce of ecological restoration projects regarding ecosystem services. In the city of Rio de Janeiro, 215 residents from three adjacent communities in areas undergoing ecological restoration and 15 residents from the same communities working on the restoration projects implemented were interviewed using standardized and semi-structured forms. Of the total number of respondents in the communities, 88% were favorable of ecological restoration and their motivations are related mainly to the benefits derived from ecosystem services. Regarding the use of forest species, 43% of the residents and 87% of the project workers use species for food, medicinal and ornamental purposes. In addition, 44% of the residents and 60% of the workers use the forests for leisure. Of the benefits from ecosystem services, 95% of residents and 100% of workers believe in increasing these benefits through restoration and the most appreciated benefits are related to cultural (beauty and leisure) and regulators (climate and air improvement) services. The broad recognition of ecosystem services can facilitate the implementation of restoration projects and enable the conservation and success of new forest matrixes, especially in urban areas where there is a greater influence of human activities and an increasing demand for ecosystem services.

T05-P05 - Assessing the knowledge, attitude and community participation of the Ogoni people in ecological restoration

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Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded or destroyed using the processes of remediation, reclamation, rehabilitation, and restoration. Although a restoration project may affect different people in different ways, the people who are affected by it need to understand the reason for restoration and appreciate its value. Thus,

the decision to restore should involve all parties and stakeholders, financiers and the public (especially the affected community). This study attempts to look at the knowledge, attitude and community participation of the Ogoni people in the launched ecological restoration exercise in the area. Data was collected using structured questionnaires. A total of 825 questionnaires were administered in Bodo, K'dere and Bormu towns in Ogoniland. 48% of the respondents had lived in Ogoni land for more than 25 years. Majority of the respondents had poor knowledge of the clean-up process especially with reference to the duration of the clean up and a reference ecosystem to which the land was being restored. The general perception of the people reveals that a greater majority had negative perception (77.5%) due to lack of trust in the government and inadequate education and awareness. Community participation and interest was low (34%) amidst the proposed livelihoods packages in the UNEP implementation report. Thus, community's knowledge, attitude, and participation need to be studied further to improve their awareness into better and responsible manner. More targeted and well-organized educational campaigns are needed to improve this trend.

T05-P06 - Restoration and food security through agroforestry systems in Maranhão, eastern Amazon

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Rural poverty and land degradation are strongly correlated in the Amazon region of Maranhão- the Brazilian state that registers the worst social indicators. Slash-and-burn agriculture is the main source of livelihood in small farms but also the main driver of degradation. In this context, Agroforestry Systems or AFS (the consortia of annual agricultural plants with trees) are an attractive alternative for restoration, allying ecosystem services reestablishment and food security. In 2014, we set up 12 experimental plots (30x30m), 6 of AFS and 6 of control (area protected for natural succession) in blocks in very degraded soils of the UEMA research farm in Sao Luis. In the two first years, AFS plots were planted with 16 tree species of local interest and availability (6 fruit, 5 timber-producing, 3 N-fixing and 2 other) in a density of 1.588 trees ha⁻¹. The agricultural species associated were corn (*Zea mays*), beans (*Canavalia ensiformis* and *Cajanus cajan*) and manioc (*Manihot esculenta*). Tree survival and growth have been monitored each 4 months since planting, and due to accidental fire episodes, mortality was 69.6% (± 22.1) in 2015 and plots were replanted. In 2016, crop production was: *Z.mays* (3,000 cobs ha⁻¹ ± 961.9), *C.ensiformis* (198.1 kg ha⁻¹ ± 80.4); *C.cajan* (13.9 kg ha⁻¹ ± 19.9); *M.esculenta* (2,025.9 kg ha⁻¹ $\pm 1,240.9$). In deprived communities, forest restoration must be a process that combines environmental and social gains. Our preliminary results suggest that AFS are a strategy that can restore a diverse tree cover reducing costs through the engagement of communities.

T05-P07 - Linking technical and local knowledge for informal ecological restoration learning in the Upper Xingu region, Brazilian Amazon

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Local knowledge has a crucial role for successful ecological restoration actions. Although there are increasing efforts to consider the role of local communities, there is a lack of information about the role of young people in restoration. Consequently, developing informal learning for young people is essential for empowerment and information access. We aimed to identify local knowledge to support an informal ecological restoration learning process for young people of the Upper Xingu region in the Brazilian Amazon. A workshop was developed with 30 young stakeholders from four indigenous communities, four rural settlements and three cities in December 2015. Young stakeholders were invited to reflect on their reality and perspectives in the restoration context, supported by the question: what would I like to learn and what am I able to teach? Participants answered this question by writing or drawing, and then they shared their thoughts in small groups. Overall, six main learning themes were identified, involving: cross-cultural exchanges, professional skills, recreation activities, environmental sensitization, computer skills, and artistic expression. Indigenous young people reported restoration learning must consider their own cultures in those techniques, such as myths, rituals, and nature indicators. On the other hand, young farmers considered that restoration skills should focus on professional skills, especially for creating local opportunities (i.e., local jobs and household cash income) which could reduce the current high rate of rural exodus. The results of the workshop suggested that standard techniques must be adapted considering local experiences and culture to integrate young people in restoration processes.

T05-P08 - Native medicinal and food species with potential for forest restoration

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The objective of this study was to identify native tree species that produce some non-timber forest resources, aiming to their management and exploitation in forest restoration systems, thus possibly contributing to income generation for small landowners. The research was carried out in the Environmental Protection Area - APA Tejuapá, Corumbataí e Botucatu (SP, Brazil), where Atlantic Forest occur. From the list of native species in the APA management plan, we identified those mentioned in the literature by their uses as medicinal, for food or other non-timber forest products. To evaluate these species, those that have interests in public policies of the Brazilian government were selected, since they already have commercial potential. Finally, these species of interest were assessed on the basis of the parameters of sustainable use, to evaluate if it is possible to manage these resources in restoration projects. From the total of 329 species identified in the region, 219 species have medicinal and 110 can be used as food. Moreover, 68% of these species are trees, demonstrating the high diversity of species that could be used in forest restoration projects. However, from the total number of plant species detected, only 25 have been subject of public policies, and only 8 species have sufficient studies for sustainable exploitation in the study region. Public policies towards management and use of native species shall be reinforced, aiming at to enlarge the set of species that can be used in restoration projects and provide some benefits to the landowners, besides ecological sustainability.

T05-P09 - Study on social-ecosystem resilience of closed mine in eastern China: A case of Dahuangshan mining area

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The depletion of coal resources in the eastern plains of China and the policy requirements of the tackle industrial overcapacity has accelerated the closure of coal mines, and the regional economic development need to be transformed. Rapidly addressing the social, ecological and economic problems caused by mining activities is the key to regional development. The series of problems are handled by the basic resilience theory.

Firstly, it puts forward the connotation of closed mine system resilience: Because of the rupture of coal-industry chain and the damage of land, ecological and environmental caused by resources exploitation, the mine becomes a compound social-ecosystem that is far from the equilibrium state. The closed mine system resilience refers to the ability to restore the original-equilibrium and the ability to across the systems threshold to reach a new equilibrium. Taking the Dahuangshan mining area of Xuzhou in Jiangsu province of China as an example, Thought the comparison and analysis, the basic characteristics of the closed mine system is concluded. Natural ecosystems were degenerating, the mining wasteland was increasing, The People's living standards and the regional economic output were declining. Using the method of Principal Components Analysis, the disturbance factors were analysed. The shock factors of the ecological subsystem included soil secondary salinization, soil acidification, soil pollutant migration, water quality deterioration, groundwater level drop, and vegetation degradation. The shock factors of the socio-economic subsystem included industry succession, land planning, population migration, policy interventions. Multi-factor comprehensive evaluation method was adopted to assess ecological resilience. The alternative indicators of natural ecosystem resilience were consisted of dive depth, pH, pollutant content, water quality index concentration, groundwater depth, vegetation coverage. And alternative indicators of socio-economic ecosystem were composed of the proportion of industrial output value, the transfer of the new planning, surplus labor, and policy effects. The results showed that the key node of the transfer of the mine ecological system is that the natural ecosystem began to change to the mining ecosystem in 1958, the mine ecosystem entered into the new stage from 1999, and the regional socio-economic stability stage began in 2009. Through the evaluation of the substitution index method, the change trend of the resilience of the Dahuangshan mine system showed that natural ecological system resilience was decreasing, and socio-economic system resilience was rising. The regional planning and policy is the mainly factors to transfer ecological and drive system development. Finally, it puts forward some measures and suggestions based on the ideal scenario for the resilience management of Dahuangshan mining area. Future development should focus on improving the adaptability of the system focal scale, develop the industrial economy, improve the miners' employment rate, and push policy advantage.

T05-P10 - Socioambiental restoration in urban environments of Patagonia Argentina

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In the north of Patagonia, the Province of Neuquén has severe and very severe levels of desertification in 3.553.000 ha (36,5% of surface). Since 1880, the native Mapuche population was almost exterminated, the new settlers overloaded the cattle fields beyond the possibilities of the arid ecosystem. In the last decades, an intense oil exploitation with high environment impact was also implemented. These socioenvironmental changes brought a profound modification in the natural and social components of the territory, that were manifested in a severe degradation of the natural environment and social conflicts. Then, a socioenvironmental restoration requires a change of social conceptions about the importance of the arid environments.

In this context, in the Neuquén city, a consortium of 180 industries and companies and the civil society made a pact for establish ecological reclamation and xerophytic gardens projects. The work was based on the consensus of the consortium (that coordinates the use of space in the industrial park), the cooperative (that made the restoration work), primary schools (that receive environmental education) and researchers of the National University of Comahue (that research about restoration technics). After some meetings among them, the cooperative generated designs in 3d digital format and two projects were already implemented. Design models, species used, and map of involved social actors are presented.

T05-P11 - Low-cost, sustainable methods of revegetation for erosion control are implemented by Ecuadorian Kichwa community using locally available materials

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Working in community, agrarian Kichwas of Cotopaxi province in the Ecuadorian Andes are using native trees and shrubs, wood stakes, locally-woven erosion mats, and rock supply to revegetate eroding slopes. Erosion, caused by road construction, placement of water supply infrastructure, vegetation burning, and crop cultivation on steep inclines, is prevalent throughout many montane cloud forest areas. Costs and lack of effective techniques have been barriers to corrective action. In 2009, during Engineers Without Borders irrigation work, EWB members and villagers began discussion of erosion control projects. The projects, jointly implemented in 2012 and 2013, included native tree and shrub plantings, installation of contour ditches to promote water infiltration, placement of erosion control mats, and installation of live-stake woody barriers and wind breaks. Village students grew out 300 hundred native woody species from stake clippings. The community built rock structures which included plunge pools, check dams, cross vanes, bank armoring, and toe walls. Local education included field trips and class room instruction, distribution of booklets documenting appropriate native plants for erosion control, erosion control techniques, and the community's project work. During the 2015 EWB monitoring trip, most sites were in good to very good condition with very satisfactory plant growth and greatly increased soil stability. Enma Sacatoro, a village woman and recent university graduate with a concentration in environmental protection, now directs revegetation for erosion control throughout a wider area.

T05-P12 - Ecological restoration in high mountain ecosystems: case study National Park Natural El Cocuy

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El Cocuy National Park is located in the Eastern mountain range of Colombia in the departments of Boyacá, Casanare and Arauca. Its height range is 600 to 5330 m.a.s.l., with the highest perpetual snows of the Eastern mountain range, encompassing strategic high mountain ecosystems, threatened at the present due to anthropogenic activities such as agriculture, livestock farming, mining and unregulated tourism. As a result, restoration actions have been carried out on three sites prioritized: Infiboy, Chorrerón and Hoya de Muletos, which have undergone anthropogenic intervention and part of the natural recovery area on the western side of the El Cocuy National Park in the Municipality of Güicán. A participatory diagnosis of these areas was carried out, identifying stressful factors and constraints, where different vegetation coverages were identified: grasslands, dense her-

bazals, shrublands, and open low forest. The restoration scenarios and their respective strategies are based on stepping stones and corridors. Also, a monitoring plan was formulated to ensure recovery and increase of the affected coverages, based on the implemented strategies. Finally, the restoration should serve as a pilot and strategic model for the recovery of biodiversity and ecological structure of paramum ecosystems.

T05-P13 - Environmental perception and involvement of family farmers in the restoration of the Amazon Forest (Rondônia, Brazil)

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Restoration success strongly depends on the involvement of local stakeholders, such as the landowners. Restoration of the tropical forest has been carried out in the region called Zona da Mata Rondoniense, with the involvement of family farmers. The rural properties in that region are highly relevant for the regional economy, meeting the demand of the urban population. Aiming at to assess the environmental perception and engagement of family farmers in the restoration actions, we applied the Collective Subject Discourse method, provided by DSCSoft 1.1.0.0 software. Interviews were applied to 26 family farmers, using open questions aimed to elucidate the following aspects of the relationship between these local stakeholders and their environment: a) perception of the landscape and the environment; b) understanding of the ethnoecological dimensions in the process of degraded-areas recovery; c) development of innovative strategies to promote adherence to the restoration activities; d) evaluation of forest restoration efficacy in their properties. The analysis resulted in 13 central ideas. Issues related to the environment appear as Central Ideas in the speech of farmers in all dimensions addressed. We verified that family farmers can carry traces of peasantry, having the countryside not only as a space for production and income generation, but also as a way of life in close relationship with the natural environment. This perception contributes significantly to the success of ecological restoration interventions.

T05-P14 - Use of traditional knowledge to ecological restoration of ferruginous rupestrian fields in the Iron Quadrangle, Brazil

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In spite of the high biodiversity, Brazilian rupestrian fields (cangas) have been extremely impacted, mainly by mining. The soils are shallow, dystrophic, with a superficial crust and high metal content (especially Fe, Al, Cu, Mn, Zn). Exotic species and fertilizers are used for canga revegetation, resulting in ecosystems whose ecological services differ greatly from the natural ones. This study was carried out in Ouro Preto, southeastern Brazil. The local agriculture is based on the family agriculture model, using agroecological methods. This study investigated the traditional ecological knowledge (TEK) of canga soil management that could be applied in ecological restoration of these areas. Ethnoecological methods (semi-structured interviews, guided tours and participant observation) were used to interview farmers chosen by the snow-ball technique. Two main technologies are used: Soil transposition and organic fertilization. The TEK associated to soil properties encompasses the perception of the characteristics: Color, density, texture and moisture. The adoption of these technologies allows the cultivation of several species, which would not be able to establish in the untreated soils. The community reveals a wide knowledge about plant species with utilitarian value adapted to the canga environments. Soil and plant analyzes will be performed to confirm the efficiency of the traditional technologies and to verify if the consumed species are according to food safety standards. The employed traditional technologies seem to be environment-friendly and efficient for canga revegetation, easy to be replicated and low-cost. In this way, ethnoecological studies seem to be an efficient tool for ecological restoration of cangas.

T05-P15 - Stakeholder's perception about dryland and forest restoration at local scale, Central Chile

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Native forest degradation is an environmental issue that causes loss in biodiversity and provision of ecosystem services; for this reason ecological restoration is considered a global priority. To unite perception (interests, values and concerns) of stakeholders regarding restoration ecology is essential for successful restoration efforts. The objective of this work was to study and compare the perception of different stakeholders interested in dryland forest restoration in Central Chile. Semi-structured interviews were carried out with 61 stakeholders from the community, experts and government institutions. The results show that stakeholders obtain and use a wide variety of native forest products directly from their properties. Also, they confer a great value to the forest and its restoration. The main concerns identified were water scarcity, land-use change, lack of environmental education, fires, and lack of public policies for the protection of native forests. All stakeholders showed great interest in participating in restoration initiatives. The restoration targets identified by stakeholders were: biodiversity conservation, maintenance of watercourses, sustainable forest use and educational-recreational use. Restoration must begin in the ravines for the community, while restoration must begin by restoring landscape connectivity, for experts. For government institutions restoration must begin by restoring biodiversity. This information is essential to prioritize areas to be restored at local scale, it may be a reference for the prioritization of areas in central Chile and it is also useful for land management and land use planning.

T05-P16 - Operation Crayweed: raising awareness about underwater forests in Sydney and beyond

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Seaweed forests are among the most productive ecosystems on earth and support important ecosystem services such as fisheries production. In Australia, seaweed forests underpin the Great Southern Reef (GSR), an interconnected system of temperate reefs that span 8,000 km of coastline. Although the GSR is valued at \$10 billion per year and about 70% of Australians live alongside it, seaweeds and the GSR have been historically undervalued. Our 'Operation Crayweed' project combines science, community engagement and art to raise awareness about the importance of seaweeds through the restoration of crayweed (*Phyllospora comosa*). Crayweed disappeared from the Sydney coastline over 30 years ago, probably as a result of urbanisation and sewage pollution. We have developed a method to successfully restore crayweed and are now using this good-news restoration success story to engage local communities and boost public awareness about the importance of seaweed forests. After a successful crowdfunding campaign, we established a citizen-science project whereby recreational divers are driving the restoration and monitoring of entire crayweed sites. We collaborated with artists Turpin+Crawford to create a 500 m art installation in iconic Bondi Beach during a 'Sculpture by the Sea' event (2016), which attracted over 450,000 visitors. This art-meets-science collaboration included a series of workshops and activities with eight local public schools and a childcare centre, with over 100 children participating. By championing outreach and educational activities, our project aims to significantly increase public awareness of marine habitat degradation and the role of science and the community in facilitating recovery.

T05-P17 - Traditional knowledge and biodiversity maintenance of the ethnia Shipibo Konibo - The preservation of species by its use

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The Peruvian Amazon occupies 61% of the territory inhabited by 2.2 million people among indigenous peoples and riverine populations. The Shipibo Konibo ethnic group is the largest ethnic group present in the State of Ucayali. Subsistence activities are made on the basis of farming tips and burning, hunting, fishing and handicrafts. The objective of this work was to document the agricultural systems and land use of the Shipibo people of the village of Nuevo Paraiso, Peruvian Amazon, evaluating the

temporal presence and the use of the species. Data were collected during the visits through semi-structured interviews, visits to clearings and forest areas. Forest areas (0.5 to 2 ha) are open in places with forests in secondary regeneration due to the ease of management. The rest period of the land is short (5 years) which can lead to soil impoverishment - corresponding to one-third of the recommended minimum fallow period. Thus, there is a great presence of fast growing species (pioneers and secondary) in a forest mosaic under intense use. It was also observed the presence of plant species as: ayahuasca (*Banisteriopsis caapi*) (hallucinogen); copaiba (*Copaifera langsdorffii*) (wound healing); ojé (*Ficus insipida*) (antiparasitic); malva (*Malva sylvestris*) (fever) among others in the vicinity of the village and in the backyards. The landslide and burning system is, by far, the one that maintains the greatest biodiversity within the production areas. The knowledge of the species makes its maintenance is desired and useful contributing to the maintenance of the species in a functional mosaic.

T05-P18 - Interconnecting Earth stewardship: Natura, an online community-based ecological restoration platform

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Natura is an online platform that incentivizes community-based ecological restoration, conservation and restoration agriculture by facilitating community access to knowledge, funding, and networks. Many plants and animals that have traditionally provided communities with valuable ecosystem services have been lost or severely depopulated due to environmental degradation. We aim to empower communities by handing them institutional tools they can use to re-introduce and maintain these species in natural ecosystems, enriching their environment by actively shaping it into a sustainable source of sustenance. The platform consists of four main features: A networking tool that connects communities with NGO's, scientists, journalists, activists, stakeholders, and each other, facilitating mutual support and the sharing of knowledge; An open-source database that provides access to practical scientific knowledge while serving simultaneously as a way to collect ecological data and to conserve traditional ecological and ethnobotanical knowledge; An interactive map that can be updated with real-time environmental data that contains a visualization of the progress and achievements of restoration communities; A crowd-funding platform that allows communities to draw in funds by telling their story to the general public and by showcasing their efforts. Our goal is to decentralize natural resource management by offering communities a larger stake in maintaining plant and animal populations that are central to their environment, culture and livelihoods. We believe that this platform can aid in making Earth stewardship a commonly practiced form of employment, connecting people around the world to preserve the Earth's abundance for future generations.

T05-P20 - Motivations for social participation in ecological restoration projects: A systematic review and assessment of its incorporation in Brazilian National Plan for Native Vegetation Recovery

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Several aspects need to be addressed to ensure that restoration projects are successful, among which social participation. Understanding what motivates people to engage in restoration projects is fundamental to broaden social participation and to increase project success. However, we still know little about the drivers of people's participation in restoration, and how we should act to boost engagement in specific projects. To contribute with this knowledge gap, this study proceeded in two steps. First, we identified the main motivational aspects for social participation in ecological restoration through a systematic review of published articles. We then classified these aspects into six categories of motivators: economic, psychological and cultural, environmental, training and awareness, inclusion in the decision-making process, and prior participation. Next, we evaluated if and how these aspects were considered in the Brazilian National Plan for Native Vegetation Recovery, an initiative aimed at encouraging forest restoration in properties in disagreement with the environmental legislation. Among the eight strategies proposed in the Plan, five serve to motivate social participation. Comparing these five strategies with our review results, we identified two neglected categories of motivators (i.e., psychological and cultural, and environmental motivators), while the others (i.e. economic, training and awareness, inclusion in the decision-making process and prior participation) were considered in

full or partially. This analysis indicates the Plan deals with aspects aimed at promoting social participation, although addressing other motivational strategies might increase success. As our example suggests, the framework of motivational aspects can guide future restoration projects and plans.

Ecological processes and ecosystem functioning

T07-P01 - Performance of *Abies religiosa* seedlings of different altitudes in a provenance trial under the canopy of nurse plants in the Monarch Butterfly Biosphere Reserve, México

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Sacred fir (*Abies religiosa*) temperate forests are shortly distributed and suffer accelerated degradation due to climate change and anthropogenic pressures. Nevertheless, these forests are essential because they provide important hydrologic services and also harbor the wintering sites of monarch butterfly (*Danaus plexipus*). Previous research predicts a severe reduction of the climatic niche of sacred fir under future climatic change scenarios. Therefore, we intended to determine the effect of an altitudinal transfer of ten provenances of *Abies religiosa* on growth, development and survival, also considering the influence of nurse plants. In July 2015, a reforestation trial was carried out in the Monarch Butterfly Biosphere Reserve at 3440 m asl with seedlings from 10 provenances taken along an altitudinal gradient (2850 -3540 m asl). Ten blocks were planted with 360 seedlings, half of them with a nurse plant treatment; we measured plant height and diameter every two months. We also measured environmental temperature, soil moisture, forest cover and needles chlorophyll content for each block. We developed a visual stress index that ranged from one (no apparent damage) to six (total damage). Two years later we recorded 88% of survival under nurse plants and 63% in control blocks. Height of individuals differed among cover treatments ($P = 0.0001$). Lower altitude provenances showed greater stress and average stress value of seedlings with and without nurse plants was 2.5 and 4.3 respectively, which supports nurse plants as a successful strategy for restoration of this forests.

T07-P02 - Local and landscape drivers of recolonization of second-growth forest by epiphytes in agricultural landscapes of the Atlantic Forest

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Second-growth forests represent the majority of the global forest cover and the main repositories of biodiversity in human-modified landscapes. However, little is known about their potential to support the recovery of epiphytes communities and the main drivers of it. Here, we assessed the local and landscape drivers of recolonization of second-growth forest by epiphytes in agricultural landscapes of the Atlantic Forest. We sampled macroepiphytes (i.e. plants observed in tree trunks with binoculars at the ground level) in 44 second-growth forest plots in remnants of semideciduous seasonal forests in agricultural landscapes of southeastern Brazil. We used Random Forests to identify the effect of forest type (second-growth forests established in abandoned pastures, abandoned silvicultural plantings or mixed tree plantings), forest age, tree basal area and soil fertility on macroepiphyte abundance and richness. Forest type was the major factor influencing macroepiphyte abundance and richness, and second-growth forests established in abandoned pastures showed the highest diversified communities. Tree basal also influenced macroepiphyte abundance, but surprisingly, forests with lower basal area showed more macroepiphytes. Our findings may help to identify second-growth forests with higher potential to conserve epiphytes communities in tropical agricultural landscapes.

T07-P03 - Climber assemblages on disturbed tropical forests: An issue to be addressed regarding forest management

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Climbers constitute a significant component of tropical forests. However, some ruderal species may recruit vigorously on disturbed areas and arrest succession. In these cases, management actions are required to restore ecological processes and take succession back on track. We aimed to assess the relationship between climbers' diversity (Fisher's alpha diversity index) and forests size and age, as an attempt to identify the drivers of climber's diversity in human-modified landscapes. We evaluated climber assemblages in 16 forest fragments within a sugarcane landscape with 10% average forest cover. We identified and registered all climbers ≥ 0.50 m height and < 3.18 cm diameter rooted in ten 25 m² plots per fragment. Forests size ranged from 2 to 120 hectares and sites were divided into two age categories: < 50 years (eight sites) and > 50 years old (eight sites). Dominance-diversity curves showed lower richness and higher dominance of climber species in youngest forests, for which we also observed higher diversity variance in comparison to > 50 years sites. However, linear models comprising size and age separately and their interaction were not significant. Our results highlight the disturbance-adapted nature of climbers, revealed by the dominance of few species in youngest forests, and the stochasticity of its assemblages' successional trajectories when forests are exposed to recurrent disturbances. Studies focusing on climbers' assemblages and their impacts on forest succession may provide relevant guidelines to climber's management, supporting restoration actions in disturbed forests. This is a promising approach to ensure forest regeneration and biodiversity conservation in historically disturbed landscapes.

T07-P04 - Water relations and carbon dynamics of tree species are affected by structure and species diversity of restored forests

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Restored ecosystems need to have not only their biodiversity and structure recovered, but also their functioning properties. Nevertheless, the effectiveness of different forest restoration systems are often measured only by silvicultural parameters, such as survival and growth of planted trees, besides the biodiversity and structure of restored community. Functioning indicators have been less explored. These are particularly important in seasonally dry ecosystems, where water availability imposes a limitation to plant establishment and growth. We investigated variables related to the carbon dynamics (carbon isotopic composition) and water relations (leaf water potential) in seven tree species of different ecological groups, growing in three restoration systems with contrasting structure: a high diversity plantation, an agroforestry system and a mixed plantation with commercial timber and firewood species. Our research question was to know whether restoration systems biodiversity and structure would provoke different ecophysiological species' responses that could affect carbon and water relations of the whole system. The experimental area is located in the center-south region of São Paulo state, Brazil, within the seasonally dry range of the Atlantic tropical forest. The preliminary results indicate a key role of restoration systems' structure and diversity in favoring a higher efficiency in carbon accumulation and water adjustment of the investigated species, no matter their functional group are. Results will have important practical applications, as ecophysiological responses of planted species will affect the ecosystem functioning as a whole, as well as will indicate the silvicultural performance of those species individually, aiming at increasing ecosystem services of restored forests.

T07-P05 - Functional types of plants and functional diversity in the understory of reforestations for rehabilitation purposes in El Porvenir, Hidalgo, México

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The study of functional diversity and functional groups of plants is a useful tool in the identification of important ecological characteristics in the recovery of a community. In the present study the objectives were the identification and description of the functional types of plants in the understory, besides characterizing the functional diversity in three reforestations of *P. greggii* of different ages, a reference site and a degraded site. To achieve these objectives, field surveys were carried out, where sites

of 100 m² were established to measure the shrub stratum and 1 m² for the herbaceous stratum. Twelve traits were selected to provide indirect information on ecophysiological-functional processes for the total of 44 species identified in the understory. With the information about abundances of species-traits a matrix was constructed, and using the InfoStat software, the dendrogram was constructed and the indexes were calculated through the FDiversity program. It was possible to distinguish three functional types of plants (TFP's): 1) Herbaceous, 2) Succulent and 3) Perennial shrubs. It was observed that the functional diversity increases as the age of the reforestation does, and the indexes that presented significant differences were FAD1, FAD2, FDC, Fric and FEve, whereas for the indexes FDis and FDiv no such differences were presented between the conditions Studied. The evaluation of the species present in the understory and the knowledge of its function in sites under reforestation is important to understand how successful the rehabilitation projects of degraded sites can be.

T07-P06 - Fruit production of animal-dispersed trees species in young forest restoration sites

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Animal-dispersed trees are recommended for tropical forest restoration aiming to attract seed dispersers, however there is a limited understanding about trees fruiting in young restoration plantings. We assessed fruit production of animal-dispersed trees species in forest restoration plantings located in Itu-SP, Southeastern Brazil. We marked from eight to 11 animal-dispersed trees species in six restoration sites, with varying age from three to eight years old, totaling 17 species. For each species, we evaluated at least six trees regarding presence/absence of ripe and unripe fruits, and production intensity in a zero to four scale. Also, we evaluated the first fruiting age, periodicity, and intensity of fruit production for each species and fruiting periodicity and intensity for each restoration planting. We found a high variation in fruit production for the studied species, and a low intensity and frequency fruiting in young restoration sites. From the 17 studied species, just three bore ripe fruits constantly, one species had sub-annual fruiting, six species had annual fruiting and five species had no fruit production in any of the studied sites. The older plantings had more species with fruit; however, fruiting uniformity did not increase with planting age. Besides, for many species, fruiting intensity and the percentage of trees bearing fruits decreased in older plantings. Lower fruiting intensity in older plantings may be related to lower levels of irradiance in those sites, suggesting a trade-off between floor shading and fruit production.

T07-P07 - Overstory phylogenetic diversity effects on early performance of enrichment planted seedlings in tropical forest restoration

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Tropical forest restoration usually implies planting trees that will create the appropriate conditions for the recruitment of other forest species in the understory and trigger secondary succession. However, many old-growth and/or valuable timber species do not recruit in restoration plantations and enrichment planting of those species is required. Since species-specific information on planting performance is lacking for many species in high-diversity tropical forests, it is important to explore tools that may aid in the prediction of species performance. We conducted phylogenetically-explicit enrichment planting experiments in the Brazilian Atlantic Forest with six to 12 species beneath a mixed-species plantation with 19, 58 and 107 tree species to assess if the mean phylogenetic distance of each seedling species to the overstory affected seedlings performance. Seedlings performed better when overstories were on average closer relatives to them in the mixed-species plantations, but this result was mainly driven by differential light availability in the understory due to lower canopy openness in treatments with a higher number of overstory species. In high-diversity restoration plantations the effect of phylogenetics may be diluted. Influences of overstory diversity on light absorption by the canopy may act as a stronger factor controlling early understory regeneration in mixed-species plantations than biotic interactions and competition.

T07-P08 - Dynamics of aboveground biomass in restoration areas of Atlantic Forest

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In times of increased carbon emissions and global warming, restoration actions play one important role in sequestration of carbon from atmosphere and retaining it in the ecosystem. As carbon represents 50% of aerial biomass in tropical forests, understanding the causes and effects of dynamics of aboveground biomass (AGB) is an important step for planning the management of tropical forests and the mitigation of global warming. In this study, we evaluated the relative effects of demography (individual and species turnover, richness, mortality, recruitment and relative growth) on the variation of AGB in forests under restoration in order to predict possible limitations of restoration projects in sequestering carbon. We assessed the richness, species turnover, demography and Δ AGB (in a 5-years interval) in trees occurring in a chronosequence (7-17, 20-30, 30-55, e >80 years) of regenerating Atlantic Forest in Southern Brazil. We used mixed models to select the variables that more influenced the Δ AGB. Our results showed the Δ AGB tend to decrease from the initial phases to the advanced successional trajectory. Mortality and recruitment rates, and species turnover slightly affected the Δ AGB, whereas species richness was negatively related to Δ AGB. These results suggest that AGB and carbon sequestration are possibly limited during the restoration process, with as initial ages presenting greater Δ AGB. Thus, future restoration projects should be considered as a change without a carbon network over time to ensure restoration effectiveness.

T07-P09 - Mangrove roots decomposition in mangrove restored site on Terminos Lagoon, Gulf of Mexico

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Recent studies mention that the decomposition of fine roots in mangroves is the most important process in the accumulation of organic matter to increase soil elevation and carbon sequestration. In a coastal lagoon in the Gulf of Mexico (Terminos lagoon, Campeche), a mangrove restoration program was carried out through the rehabilitation of hydrology to improve soil biogeochemical characteristics. A study of the decomposition of roots in restored sites versus natural sites was carried out, in order to evaluate the accumulation of organic matter and biogeochemical recovery of the soil. For this, buried decomposition bags of 0 and 40 cm of soil depth were used, with an initial sample of 15 g of fresh roots of *Avicennia germinans*. The decomposition rate was represented at different timescales for 360 days. As a result it was observed that the roots decomposition rate was higher at the restored sites and ranged from 0.0016 to 0.0018 g day⁻¹ compared to the natural sites with 0.0011 g day⁻¹. To determine the relationship of environmental factors associated with root decomposition, a analysis of principal component was performed, determining that there was a negative relationship of decomposition rate with salinity and temperature, in contrast to the soil redox potential at a depth of 30 cm. These factors associated with the decomposition process are the result of restoration actions through the recovery of hydrological dynamics in degraded mangroves

T07-P10 - Implications for wind management in restoration ecology: Linking ecosystem aerodynamics to physiological drivers in arid and semi-arid systems.

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Restoration efforts in arid and semi-arid ecosystems continue to remain limited by high seedling mortality. The physical conditions of these environments are heavily altered by previous land use, and often characterised by strong winds. While many factors (soil, water, seed genetics) are well understood and heavily manipulated during restoration practice, incorporation of ecosystem aerodynamics remains far under-utilised. The investigation identified canopy flow wind regimes across several native Australian vegetation communities, and mapped the decay and regeneration of aerodynamic wind patterns across a restoration chrono-sequence. A seedling, historically adapted to emerge in a less windy environment, is likely to experience high levels of

stress when seeded on restoration sites with extreme early-stage wind regimes. Physiological trials indicated significant impact of increased wind velocity on seedling mortality and biomass, and explored mechanistic drivers connecting localised aerodynamic flow and vegetation establishment. A more comprehensive understanding of wind as a factor in restoration will allow for anthropogenic manipulation of wind and microclimates onsite, provide necessary shelter for seedlings until sufficient canopy features have established, and facilitate a more rapid and efficient reintroduction of plants, pollinators, and functioning ecosystem services.

T07-P11 - High nutrient loads amplify carbon cycling across California and New York coastal wetlands

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This project was catalyzed by observations of pervasive marsh subsidence at a eutrophic California estuary with high nutrient inputs in spite of robust sediment accretion patterns. We hypothesized that the high nutrient loads might be negatively impacting marsh survival through reduced belowground biomass production and enhanced carbon mineralization. We tested this hypothesis by characterizing belowground productivity and decomposition, carbon mineralization rates, soil respiration rates, microbial biomass, humification, soil C, N, and P inventories, N isotopic ratios, and reactive porewater profiles at high and low marsh elevations across eight marshes in four estuaries California and New York that have strong contrasts in nutrient inputs. Porewater DIN levels were not consistently higher under more N enriched conditions, although soil $\delta^{15}\text{N}$ ratios were much higher, suggesting that plant assimilation and denitrification rapidly removed N inputs. Overall the higher nutrient load marshes were characterized by faster carbon turnover, with higher belowground production and decomposition and greater carbon dioxide efflux than lower nutrient load marshes. More rapid C cycling has a number of implications for wetland ecosystem functions, and may predispose wetlands to vegetation die-back where low elevations are combined with poor water quality, as more rapid heterotrophic decomposition can result in elevated porewater sulfide concentrations.

T07-P12 - Using a deforestation chronosequence to understand changes in stream habitat structure and fish diversity: implications for ecological restoration

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Deforestation is a primary driver of habitat loss and fragmentation affecting terrestrial and aquatic ecosystems. The primary effects by which deforestation influences stream features (i.e. habitat simplification or homogenization) do not occur immediately after logging and populations of many stream species may also not respond immediately to changes in instream habitat. Adopting a chronosequence approach may allow for detecting temporal responses to deforestation without monitoring for extensive periods of time. The chronosequence approach has been frequently used to study biodiversity structure and functioning (mostly of plant and soil communities) during succession or after restoration. In this study, we used a deforestation chronosequence to investigate how time since reaching a 40% deforestation threshold affected instream habitat structure and species richness of sensitive (SSR) and tolerant fish species (TSR), defined by TITAN analysis, from 75 streams in the western Brazilian Amazon. Deforestation degree at watershed and riparian zone was derived from remote sensing techniques for multiple periods (1984 to 2011). Forest-derived instream habitat (litter-packs, wood-debris) and SSR decreased rapidly following 40% deforestation or the maximum deforestation period. In contrast, grass and sand habitats and TSR increased following a 5-10 year time lag. For reforestation to also indirectly benefit stream quality and diversity, it is important to halt or reverse deforestation prior to reaching the critical threshold affecting instream habitat structure and associated biodiversity. Restoration of instream structure and functioning through forest regeneration will likely take substantially more time once the threshold has been passed.

T07-P13 - Dry season as a biological filter in seedling survival of sacred fir (*Abies religiosa*) in Monarch Butterfly Biosphere Reserve, México

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Abies religiosa forests develops under particular geographic and climatic conditions in the high mountains of central Mexico and face several risk factors (deforestation, fires, pests and diseases). Demographic studies of seedlings are basics to understand natural regeneration process. This knowledge could provide an alternative management strategy for the restoration of this stands because they are highly reforested for conservation purposes but with poor results. The objective of this project was to characterize the factors affecting survival of fir seedlings during the dry season in the Monarch Butterfly Biosphere Reserve. Thirty quadrants of 4 m² distributed in two different altitudinal ranges were marked; intermediate level from 3050 to 3300 and upper level from 3301 to 3550 masl. Seedlings less than two years old were marked and counted. The number of seedlings was counted every month during the dry season. Thickness of moss layer, soil and moss moisture were recorded. 661 seedlings were marked, 283 at the upper level and 378 at the intermediate level. A survival of 51.8% was recorded at the end of the dry season, without significance differences between altitude ranges. The highest mortality was observed in April (14.3%), coinciding with the lowest values of moss thickness layer and moss and soil moisture. The low humidity causes a series of events in different biotic and abiotic attributes of the understory, which are related with the probability of survival of seedlings. Survival is not linked with the forest structure although it is considerably different in the two altitudes studied.

T07-P14 - Influence of *Eucalyptus saligna* on the dynamics of leaf-litter production and decomposition in riparian areas

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The presence of exotic species in riparian areas can modify ecological processes and functions occurring in natural ecosystems. The objective of this study was to determine the influence of *Eucalyptus saligna* Sm. on the dynamics of leaf-litter production and decomposition in the Tinga watershed, located at the Itatinga Experimental Station (SP, Brazil). For the deposition of the leaf-litter, 12 collectors of 0.25 m² were systematically allocated on both banks of the stream. Leaf-litter from eucalyptus and native was collected on a monthly basis during one year. To evaluate leaf-litter decomposition, leaves from eucalyptus, native and eucalyptus/native, in a ratio 1:1 were introduced in litter bags. The decomposition rates were assessed every three months during a one year. There were statistical differences in leaf-litter production between treatments ($p > 0.0005$), being the amount of leaf-litter from eucalyptus significantly higher (2600 kg ha⁻¹) than that produced by native tree species (1600 kg ha⁻¹). Regarding decomposition, there were statistical differences between treatments ($p > 0.0039$), eucalyptus presented a lower rate of decomposition than other foliar types. These results show that eucalyptus has a higher accumulation of leaf-litter due to its high deposition and low decomposition rates. Therefore, presence of this species may disturb riparian zones, and its ecological processes, since the balance between leaf-litter input and decomposition could modify organic matter on soil and its interactions. Results have implications for restoration of Permanent Preservation Areas in Brazil since Forest Code allows the use of exotic species during the process of native vegetation restoration at those areas.

T07-P15 - When do lianas dominate the forest community in degraded tropical forest remnants?

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Tropical forests in agricultural landscapes have historically suffered anthropogenic disturbances that modify its ecosystems and degrade forest communities. These alterations allow the proliferation of ruderal species, such as some species of lianas, which may arrest forest succession. We analyzed the dynamics of the tree and liana communities in a disturbed remnant of semideciduous seasonal Atlantic Forest in southeast Brazil. We aim to identify in which stage of the plant life cycle (seed, seedling,

juvenile or adult) lianas become more abundant than trees in disturbed forest remnants and, thus, develop management recommendations for practitioners. We allocated 30 plots of 314 m² each in forest sectors dominated by ruderal liana species and sampled abundance and species richness of lianas and trees. Although trees are more abundant at the seed life stage, lianas seem to have less mortality when advancing through life stages. We also identified that lianas dominate forest community in degraded remnants from the juvenile stage onward. Seed rain and seed bank may not be determinant for the propagation of ruderal lianas in degraded remnants, while trees seem to rely more on germination for establishment. The high abundance of liana seedlings and juveniles in the remnant may be related to its vegetative reproduction. Interventions for the restoration of liana-dominated forest remnants must aim at the juvenile and adult stage of this life form, such as liana cutting.

T07-P16 - Photosynthetically active radiation under forest fragment and forest restoration systems in the Cerrado-Amazon ecotone, Mato Grosso State, Brazil

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In this study we monitored the Photosynthetically Active Radiation (PAR) in four treatments of a Forest Restoration (FR) project, as well as inside a Native Forest (NF) and under Full Sun (FS) condition during 651 days, in Cerrado-Amazon ecotone, Brazil. The FR systems were established in December 2012 and consisted of a consortium of 16 native species with eucalyptus (T1) and with rubber trees (T2), both with artificial pruning (AP), and only native species with (T3) and without AP (T7), all with a density of ~800 ind.ha⁻¹. The PAR data was acquired continuously with specific sensors coupled to automatic weather stations and data loggers, while tree height and shading were measured inside circular plots around the stations after four years of planting. According to the paired T test, in all treatments, the available PAR (MJ m⁻² day⁻¹) during the studied period presented significant differences ($P < 0.01$), with mean values of 5.08 (T1), 5.28 (T2), 5.65 (T3), 4.94 (T7), 7.17 (FS) and 0.19 (NF). As expected, NF had the lowest level of PAR, while the FR treatments are already showing some level of shading that will allow the gradative suppression of exotic grasses and the establishment of natural regeneration. The lowest level of PAR at T7, even with T1 having high individuals of eucalyptus, may be due to the lack of AP. However, as we expect to provide wood as a major product of the forest management, the challenge will be to balance this management with the return of natural processes.

T07-P17 - Low predictability in aboveground biomass accumulation in Atlantic Forest restoration sites

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Forest restoration has been in charge of a huge part of greenhouse gas emission mitigation, but the certification of carbon capture should incorporate uncertainties in above-ground biomass (AGB) estimations, and forecasts for longer periods (>10 years) may include unknown errors. We analyzed AGB accumulation in reforestations of different ages in order to measure uncertainty in different time intervals. Data came from 24 Atlantic Forest restoration sites around Capivara reservoir (Paraná and São Paulo states boundary, Brazil). AGB was estimated for trees using allometric models in stands ranging from 1 to 14 years. We used linear regression to verify the rate of AGB accumulation in age intervals (0-50, 51-100 and over 100 months). Only in the first interval (0 to 50 months) we found a clear increase (9.95 Mg.ha.year⁻¹) in AGB with time ($p=0.006$, $r^2=0.74$). In this period pioneer tree species are growing and management is intense. However, a much lower rate of AGB increase can be observed in the 51-100 months interval, and even a decrease when analyzing sites over 100 months. We concluded that after the first years the accumulation of biomass did not follow a predictable pattern. Mortality of planted trees, lack of recruitment of regenerating individuals and even re-invasion of non native species can be important factors influencing AGB in reforestations after two years. We suggest that there is a need for monitoring and adaptative management for longer periods in order to warrant carbon capture in reforestations.

T07-P18 - The mating system effects on seed traits, and the seedling development of *Hymenaea courbaril*

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In predominantly allogamous species ($t > 0,95$) selfing and mating between related individuals occur naturally at low rates. However, the forest fragmentation and the constant collection seeds for seedling production, have intensified leading the remaining population to inbreeding depression. Inbreeding depression is very important, because it can damage the natural populations and the new population of reforestation. To verify the effect of mating system in seedling development of *Hymenaea courbaril* L., we collected 30 fruits/seed tree of each eight trees, from natural and well preserved population. To estimate the Spearman Correlation of outcrossed, selfed and related individuals with fruit weight (FW), number of seeds per fruit (NS), weight of the seed (SW), height of seedling (HS) and root collar diameter (RCD), DNA was extracted from the same sampled seedlings and it was genotyped. The outcrossing rate presented positive correlation for NS (0.21) and SW (0.19). The mating between related individuals presented negative correlation for NS (-0.29), and positive for SW (0.53), HS (0.23) and RD (0.35). Selfing seedlings showed negative correlation for FW (-0.19), SW (-0.21) and for NS (-0.14). Thus, it is possible to note that the outcrossing rate is related the production of larger fruits and more seeds. However, in the initial stages, the development of seedlings is higher for individuals produced from mating between related individuals. It is important information for the nurseries that produce this species. Indeed, selecting larger seedlings for reforestation sites, may be founding a population of lower genetic diversity, which may cause inbreeding depression.

T07-P19 - Availability of zoochoric tree species fruits in passive and active Atlantic Forest restoration sites

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Phenology observations can be important tools for monitoring restoration sites, because they inform about plant reproductive success and availability of fruits and other foods to fauna, and generate information that can be useful in the selection of species for active restoration projects. This study aims compare the availability of fruits of zoochoric tree species for frugivorous animals in Atlantic Forest passive restoration sites (two secondary forest sites, different ages) and active restoration sites (two reforestation ages, 1979 and 2003), using forest fragments as reference sites, in north-western Parana state, Brazil. We observed fruiting behavior monthly for 24 months in 81 species, selected among the most abundant in each community, in order to verify patterns of climate dependence and seasonality if fruit availability among restoration sites and reference area. In all sites, fruiting behavior showed a positive correlation with annual average temperature and with day length. The sites that offered fruits more consistently throughout the year were the mature forest and the older secondary forest, where there was no seasonality in fruiting. However, the younger secondary forest and both reforestations presented seasonality in fruit production, therefore lacking fruits in certain periods. Overall, passive restoration sites presented greater reproductive success and greater availability of fruits for fauna when compared to active restoration sites. The younger reforestation presented the lower fruit availability, and thus an enrichment with other zoochoric species could be beneficial.

T07-P20 - Competition and facilitation processes that influence the establishment of forest species under pine forest cover

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Mediterranean ecosystems have been extensively reforested with several species of pine, mainly *Pinus halepensis*. The main objective was to establish a vegetation cover to avoid degradation processes and to promote conditions for the introduction of native species. These species may be adapted to the new conditions through facilitation processes or competition in pine forest.

Facilitation processes can improve soil nutrient and mitigate extreme temperature fluctuations. Competition processes will be mainly for resources such as light or water. In this context, five hundred plants of six resprouter species were introduced under the canopy of the pine forest to estimate facilitation or competition processes that determine their establishment. The objective was to increase the diversity and resilience of these forests against forest fires recurrent and intense droughts, in the region of Valencia Spain. The Relative Growth Rate (RGR) in height and diameter of the plants introduced at distances of 0 to 1.5, 1.5 to 3 and greater than 3 meters of the nearest pine was analyzed. It was found that there are no significant differences between RGR in height, but there are differences in diameter between species and distance classes, being higher in the majority of the species that are furthest from the pine. The results suggest that competition process for the water could determine the growth in diameter and probably the development of the root. On the contrary, the average height of the seedlings would be determined by the density of the pine regard of the proximity to the nearest pine.

T07-P21 - Restoration of overgrazed areas in the semi-arid Chaco (Argentina): studying germination requirements to grow nurse plants

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Among the dry forests of Latin America, the Chaco has the largest extent of continuous forests. People in the Chaco live by using traditional livestock management in “puestos” (groups of houses, farmyards and artificial water sources). Overgrazing causes vegetation loss and soil compaction generating areas without vegetation cover. Reintroducing thorny or non-palatable plants is useful as a starting point to create fertility islands, these potential nurse plants protect plants from grazing and improve natural regeneration. However, there is no information about the dormancy-breaking and germination requirements of Chaco plants. In order to raise new nurse plants for restoration programs in the Chaco, we studied the germination requirements of five woody species: *Castela coccinea*, *Celtis ehrenbergiana*, *Anisocapparis speciosa*, *Sarcotoxium salicifolium*, and *Cappari cordis tweediana*. Germination of each species was tested at 25°C in light (12hr light/12hr darkness) and in continuous darkness (Petri dishes covered with aluminum foil). A seed germinated if it had a 2 mm radicle, and a species was dormant if their germination percentage is lower than 80. We found that seeds of *A. speciosa* are not dormant, and those of *C. coccinea* are not dormant in darkness. Seeds of *C. ehrenbergiana*, *S. salicifolium* and *C. tweediana* are dormant; therefore, to increase their germination percentages, we are performing a seed stratification treatment. The best candidates to introduce into the puestos are *A. speciosa* and *C. coccinea* (both can be easily propagated). This information is useful to grow potential nurse plants to restore the overgrazed areas in the semi-arid Chaco.

T07-P22 - Tree diversity enhances light interception by the canopy of tropical forest restoration plantations

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The biodiversity and ecosystem functioning (BEF) theory can provide valuable information for guiding ecological restoration. However, the existing BEF knowledge cannot be directly transferred to tropical forest restoration, since most BEF assumptions are based on studies performed on grasslands and with low number of species (less than 20). In this study, we assessed if, and eventually how, tree diversity enhances light interception by the canopy of tropical forest restoration plantations. We based our study in a 9-year-old restoration plantation in the Atlantic Forest (southeast Brazil), established with 20, 59 and 113 native tree species (2160 m² plots, 4 repetitions). In dry and wet seasons, we measured intercepted photosynthetic active radiation (iPAR) by forest canopy over 3 x 6 m horizontal grids (at 1 m high), and distribution of iPAR in vertical profiles, measured every meter, up to 4 m high. Finally, we used a ground-LiDAR to measure and graphically represent vertical structure of vegetation. Overall, 20 species promoted significantly lower interception and higher spatial variability of iPAR. Mean iPAR at 1 m high was lower at 20 species (both seasons). Horizontal standard deviation (SD) decreased with richness in dry season, but showed lowest values at 59 species during the rainy period. Vertical SD was higher at 20 species only in the dry season. We conclude that higher tree diversity led to niche partitioning of PAR absorption across time and space, both horizontally and vertically, evidencing the role of tree diversity to enhance recovery of ecosystem functions in forest restoration.

T07-P23 - Effect of stand canopy composition on litterfall dynamics of native tree species plantations

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Plant species with particular functional traits can promote beneficial effects on ecosystems functioning, helping to catalyze the regeneration of native vegetation during the restoration of degraded tropical forests. Studies focusing litter dynamics and nutrients cycling may help to identify species with potential for restoration of soil chemical and physical properties. We studied the litterfall production in two stands (more than 80 years-old) of monospecific plantations of *Anadenanthera colubrina* (Vell.) and *Hymenaea courbaril* L., (Fabacea), to evaluate how the canopy species could affect litter dynamics. The study site is located at Botucatu, SP-Brazil. Both stands had similar soil and topography conditions, and *A. colubrina* and *H. courbaril* trees comprised, respectively, 49% and 1% of total stand density, and 92% and 60% of total basal area. The annual litter production was comparable to local native forests, with leaf fraction accounting for 60-80% of the total. *H. courbaril* stand had higher production and accumulation of litter than *A. colubrina*, the latter being the species that most contributed with total leaf deposition, followed by *Nectandra megapotamica* and *Piptadenia gonoacantha*. Our results indicate that, after more than 8 decades, the planted species are still the main drivers of nutrient cycling processes in either the stands, in spite of the rich tree community that has regenerated in both. Species canopy traits (leaf compoundness and canopy deciduousness) seem to account for stands differences in litter production. Nevertheless, our results indicated that both species might promote significant improvements in soil fertility, demonstrating great potential for restoration plantings.

T07-P24 - Variation of trees wood density in a chronosequence of forest natural regeneration in the Southern Brazilian Atlantic Forest

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The changes in biodiversity and forest structure during natural regeneration can influence the variation of trees wood density as well estimations of carbon storage in the forests. The aim of this work was to evaluate the effect of forest age/structure on the wood density of tree species in the Southern Brazilian Atlantic Forest. Forest plots aged of 25, 60, 75, 90, 100 and >200 years-old represent the study areas where nine tree species (with identifiable growth rings) were selected for densitometric analysis: *Alchornea glandulosa*, *Alchornea triplinervia*, *Casearia obliqua*, *Cupania oblongifolia*, *Matayba guianensis*, *Ocotea catharinensis*, *Pera glabrata*, *Virola bicuhyba* and *Vochysia bifalcata*. The four youngest plots represent second-growth forest under natural regeneration whereas the two oldest ones were never been submitted to clearcut. The wood samples were extracted with a Pressler borer before densitometric analysis. The average wood density ranged from 0,55 g cm⁻³ to 0,86 g cm⁻³. This variation resulted from the natural regeneration process where species with faster growth and lower wood density are predominant in the youngest forests where as species with a lower growth and higher woody density are more common in the oldest forests. More research should be done with other species of the Brazilian Atlantic forest regarding more accuracy on the estimation of carbon sequestration by the trees. The stage of forest regeneration is a key factor affecting the diversity of tree species in the forest as well the variation of their wood density. So these variations should be taken into account when estimating forest carbon storage for the Southern Atlantic Forest of Brazil.

T07-P25 - Ecofunctional traits and biomass production in leguminous tree species under fertilization treatments during forest restoration in Amazonia

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Choosing the correct species and fertilization treatments is a determining factor in the success of forest restoration. Methods: A field study was conducted in a degraded area near the Balbina hydroelectric dam in Amazonas State (AM), Brazil, to evaluate two hypotheses: (i) leguminous tree species exhibit differences in growth, leaf nutrient content, and photosynthetic nutrient use efficiencies; and (ii) differences in these characteristics depend on the fertilization treatments to which the species have been subjected. *Dipteryx odorata*, *Inga edulis* and *Schizolobium amazonicum* were subjected to the following treatments: (T1) unfertilized control; (T2) post-planting chemical fertilization; (T3) post-planting organic fertilization and (T4) combined chemical and organic post-planting fertilization. Results: In general, *I. edulis* had the highest absolute growth rate of biomass under all of the fertilization treatments. *I. edulis* and *S. amazonicum* showed the highest growth rates under the T4 treatment. *D. odorata* showed the greatest responses under the T2 and T4 treatments. Native leguminous trees with higher photosynthetic performance and better nutrient use efficiency exhibited greater growth and biomass production. Conclusion: The results suggest that an adequate balance between leguminous species selection and fertilization will aid in the success of forest restoration in Amazonia.

T07-P26 - Modelling the influence of winter snowfall on cyanobacterial crusts in the Gurbantunggut Desert, northern China

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Winter snowfall is an important factor in the growth and development of biological soil crusts (BSCs) in temperate desert regions of China. Climate change is altering snowfall regimes, which increases snowfall value and snowfall days in northern China over the past few years. In this study, a manipulative experiment using five levels of snow treatment — snow removal (0S), snow reduction to half that of ambient conditions (0.5S), ambient snow (1.0S), snow increase to 1.5 times that of ambient conditions (1.5S), and snow increase to twice that of ambient conditions (2S) was designed to evaluate the effects of winter snowfall on photosynthesis and the physiological characteristics of cyanobacterial crusts isolated from the Gurbantunggut Desert in the early (March) and late (October) periods after snowfall. Analyses indicated that biomass, chlorophyll (Chl) fluorescence parameters (i.e. maximum photochemical efficiency, fluorescence yield and rates of electron transport) and the concentration of soluble protein of cyanobacterial crusts declined as a result of lower soil water content resulting from snow removal or reduction. Increased winter snowfall had positive effects on physiological properties associated with photosynthesis, but induced dramatic decreases in the malondialdehyde (MDA) concentration in cyanobacterial crusts. In addition, photosynthesis of cyanobacterial crusts was obviously higher in the late than in the early period after snowfall, which can be attributed to increases in the cover of cyanobacteria in the crust communities. These findings provided evidence that increased winter snowfall in the Gurbantunggut Desert could favor and help maintain the development of BSCs.

T07-P27 - Spatial-temporal pattern of urban heat island and driving forces in China

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There are huge negative effects of urban heat island (UHI) on local climate change and ecological environment. However, the temporal and spatial patterns of UHI in a large-scale is still a pending question. Our research explored the large-scale spatial and temporal patterns of UHI in 155 cities across whole China by collecting observation data from 310 meteorological stations over 30 years (1984-2013), and charted the spatial pattern graph of UHI. We also studied the potential natural and anthropogenic factors that may drive the UHI. The results suggested that the UHI was linearly increased in the past 30 years and is strongest in summer. The UHI of inland cities were significantly higher than that in coastal cities, whereas there is no significant difference between climatic zone and geomorphic type. The

large-scale spatial pattern of Chinese UHI is resulted from superposition of natural factors and anthropogenic factors, of which natural factors such as relative humidity, wind speed, precipitation have greater effects. Our results indicate that, UHI is caused by anthropogenic influences, and intensity of UHI is correlated positively with human activities at small scale (single city), however, the pattern of UHI at large scale is resulted from natural factors. UHI is not a specific city's local ecological phenomenon, studies on large-scale spatial-temporal pattern would provide great references value on Chinese or even global UHI management and urban restoration.

T07-P28 - Methods to assess root architectural and root morphological functional parameters in tropical grasslands

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Misperceptions and lack of knowledge about the tropical old-growth grasslands (OGGs) contribute to their destruction, especially due to their conversion into agriculture or tree plantations according to current carbon compensation policies. Few is know about functioning of underground part of OGG, which limit strongly their restoration. We aim here to present how to assess distribution and diversity of root functional parameters (FP), including architectural and morphological FP at the community level, and the potential application for restoration of grassy biome. In three different OGGs from South America along a productivity gradient: campos rupestres (altitudinal savanna, lower productivity), the campos sujos (open savanna, intermediate), and the campos úmidos (wet savanna, higher productivity), we selected 3 sites. In each site, vegetation survey was carried out in 10 plots randomly established, and soil core samples were collected (from 10 cm to 2m for deeper soils) for soil analysis and root trait measurements. At the laboratory, soil and roots are separated and we determine the morphological FP measurements. Each sub-sample and the remaining roots are dried and weighed. We finally determine root tissue density, the specific root length, the root dry matter content and the root mass density for each soil-layer and assess architectural FPs: the rooting depth and the root length density. We present here the protocol to study underground functional parameters in open savanna physiognomies and present the different opportunity of such study for restoration ecology.

T07-P29 - Influence of different width of road on Nature Reserve

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Road construction in a nature reserve is generally considered to be a detrimental disturbance to forest restoration and management. However, are all the roads incompatible with forest conservation? We selected six forest nature reserves from south to north in China and assessed the influence of wide and narrow roads on plant species diversity, biomass, and soil properties along transects running from the forest edges and adjacent forest interior. Our study indicates that there are no measurable effects on biological-environmental aspects for narrow roads, so they are compatible with forest conservation. We used a "shape-dependent model" to explain what factors determine the magnitude of road effects on forests, i.e., the differences between wide roads and narrow roads is caused by road width, and road width is determined by a shape-dependent extrinsic disturbance. We deduce that the width threshold may be determined by considering the effect of roads on forest ecosystems.

T07-P30 - Litter chemistry and abiotic effects on plant recruitment success in denuded areas of Patagonian Monte rangelands

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Grazing disturbance reduces the cover of preferred species and increase soil gaps in arid ecosystems. Litter amendment is a management tool often used for soil and plant restoration in denuded areas, but its efficacy has rarely been tested in these ecosystems. We evaluated the effect of litter chemistry (C/N ratio) combined with different levels of UV radiation exposure and soil water on

soil inorganic-N (SNin) and recruitment of two dominant perennial grasses preferred by herbivores (*Poa ligularis* and *Nassella tenuis*), one preferred shrub (*Atriplex lampa*), and one non-preferred evergreen shrub (*Larrea divaricata*), that has chemical defenses against herbivores in denuded areas of the Patagonian Monte, Argentina. Microcosms with soil of denuded areas and seeds of all species were sown in separated cells, subjected to the combined effects of litter cover (without litter (NL), litter with C/N ratio =15 and C/N ratio =48), UV radiation (near ambient (Am-UV) and reduced (Re-UV)), and volumetric soil water (high (15-25% HSW) and low (5-15% LSW)). We assessed SNin concentration periodically and species recruitment (probability of transition from seed to established plant) after six months. Low C/N ratio in litter and Am-UV increased SNin. Soil water enhanced SNin only at one date. Perennial grass species and *A. lampa* recruitment was increased with augmented SNin. None factor affected the recruitment of *L. divaricata*. We concluded that litter amendment combined with exposure to UV radiation throughout the effect on soil inorganic N may modulate plant recruitment success of species preferred by herbivores in denuded areas.

T07-P31 - Effects of re-vegetation on herbaceous species composition and biological soil crusts development in a coal mine dumping site

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To evaluate effects of re-vegetation on herbaceous species diversity and biological soil crusts (BSCs) development during the process of vegetation restoration of anthropogenically damaged areas in arid and semi-arid ecosystems. The herbaceous plant species composition, along with the BSCs coverage and thicknesses, were investigated at Tree, Shrub, Tree+Shrub, Tree+Herbaceous, Shrub+Herbaceous, Tree+Shrub+Herbaceous sites and the natural vegetation site as reference of the Heidaigou open pit coal mine in north China. The highest total species richness (16), as well as the species richness (4.4), occurred in the Tree + Herbaceous site. The species composition similarities between the restored sites and the reference site were shown to be very low, and ranged from 0.09 to 0.42. However, among the restored sites, the similarities of the species were fairly high and similar, and ranged from 0.45 to 0.93. The Shrub site showed the greatest total coverage of BSCs (80%) and algae crust (48%). The significant correlation was observed between the total coverage of the BSCs, and the total vegetation and herbaceous vegetation coverage, as well as between the algae crust coverage and the herbaceous vegetation coverage ($p < 0.05$). Therefore, the re-vegetated dwarf woody plant species (such as shrubs and semi-shrubs) should be chosen for the optimal methods of the restoration of herbaceous species diversity at dumping sites with low density. Furthermore, the effects of vegetation coverage on the colonization and development the BSCs should be considered in order to reconstruct the vegetation in disturbed environments in arid areas.

T07-P32 - How biodiversity as a variable response, explain the ecosystem functioning: lessons from restored riparian forests

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Biodiversity enhances the ability of ecosystems to maintain multiple functions. The relationship between biodiversity and multifunctionality has been neglected in restoration programs. We test how ecological restoration contributed to recover the Biodiversity and thus enhance ecosystem functionality in fragments of recovered riparian forest southern Brazil. Richness, abundance and composition of mammals, birds, amphibians and reptiles, soil invertebrates, bees and wasps and plant species, seed rain, and leaf litter deposition were collected. Ecosystem function and biodiversity models were fitted. Ecosystem function included ecosystem function as the response variable and all other variables as predictor variables. Biodiversity models included vertebrate and invertebrate diversity as response variables and site level variables as explanatory variables. The greatest variation across sites occurs in invertebrate evenness and tree diversity, with the oldest sites having the highest index values. Tree evenness and vertebrate evenness is approximately the same across all sites, regardless of age and core area width. Moderate variation is present in invertebrate and vertebrate diversity, with the highest index values present in the older sites. Changes in the evenness of soil invertebrates, vertebrates, and trees as well as the diversity of bees and wasps and trees are associated

with declines in ecosystem multifunctionality, with the association between tree evenness and ecosystem multifunctionality highest in magnitude. Applying the concept of BEF will be valuable for assessing functional consequences of species extinctions for different types of ecosystem functions along the sampling sites. So we need to extend our understanding of biodiversity and ecosystem functioning to multispecies interactions.

T07-P33 - Determinism, and not stochasticity, affects tree turnover in tropical forest regeneration

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During the forest succession, changes in species composition and individual turnover may be affected by deterministic (for example, environmental filtering, species interactions) and stochastic (neutral) processes. It is not clear if these processes act isolated or synergistically in structuring plant communities. Quantifying these processes is essential for understanding the maintenance of biodiversity and the success of restoration. In this study we assessed the relative effect of deterministic and stochasticity processes structuring the plant communities during the successional trajectory of tropical forest. We assessed the demography (recruitment and survival rates in an interval of 5 years), in trees occurring in a chronosequence (7-17, 20-30, 30-55, e >80 years) of regenerating forests in Southern Brazil. We first tested for stochasticity by building null models (randomizing species composition and abundance) for each forest age. All plant communities in the chronosequence were different from null models, indicating determinism. Then, we used model selection (and Akaike Information Criteria) to assess the relative effects of environmental filtering (measured by soil type, forest age) and species interactions (measured by basal area, individual density, species richness, and phylogenetic diversity) to predict recruitment and survival rates. The best variables to explain survival and recruitment were, respectively, basal area (positive effect) and forest age (negative effect). We concluded that possibly environmental filtering (determined by forest age) affects individual fitness (determined by basal area) resulting in the structure of communities in the regenerating forests.

T07-P34 - Effects of vegetation structure on the physiological activity of understory plants in different tropical seasonal forest restoration systems

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Forest plantations have potential to modify the microclimatic conditions of degraded environments, due to increasing their structural complexity, which is considered a positive factor favoring the native vegetation regeneration. Forest canopy species, depending on their architecture, longevity and deciduousness, might affect understory microclimate in different ways, as well as physiological activity of regenerating species. We aim to understand whether different restoration systems affect the physiological activity of understory plants that are regenerating. We sampled three contrasting seasonal tropical forest restoration systems, established 19 years ago in Botucatu, São Paulo-BR: agroforestry system (20 tree species); mixed commercial plantation (25 timber and firewood species); and high-diversity plantation (40 different functional groups species). We selected three individuals per plot of six species common to all treatments (n=162 individuals). Stomatal conductance, chlorophyll a fluorescence and leaf area index were evaluated during the end of the rainy season. The results showed differences between restoration systems for chlorophyll fluorescence, with higher values of non-photochemical quenching and maximum quantum efficiency of photosystem II in the diversified system, when compared to the agroforestry and commercial-mix plants. These results show that the individuals in the diversified system have higher loss of energy in the form of light and heat than in the other systems, which can indicate a higher competition for water resources, due to higher stand stocking, which might in turn affect plant stand productivity and ecosystem functioning. Our data suggest the need for management of the canopy in those systems, in order to favor the regenerating plants.

T07-P35 - “The Society for Ecological Restoration’s Large-Scale Ecosystem Restoration Section”

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With nearly 600 members, the Large-Scale Ecosystem Restoration Section (LERS) is the largest within the Society for Ecological Restoration. Its mission is to advance public education and enlightenment of resources, provide a community of practice for practitioners, develop the concept of large-scale ecosystem restoration as a discipline, and encourage and evaluate the development and advancement of all branches of large-scale ecosystem restoration and practice. LERS has a growing international membership base that reflects the global attention on ecological restoration as a necessary component of sustainable development. LERS members give priority to learning and communicating about on-the-ground restoration techniques but are also interested in ecosystem valuation, funding opportunities, policy and governance, collaboration with other members and a network for outreach and communication of their work. As a community of practice, LERS is a diverse assemblage of restoration professionals from dozens of countries, each of whom are interested in and working on large-scale ecosystem restoration on a large geographic, sectoral, or procedural scale. LERS members provide support and inspiration to help each other address technical and administrative challenges including issues of scalability, geographic analysis, governance, and public support for large-scale restoration. LERS is primarily a way to learn and communicate with other restoration practitioners about successes and challenges in ecosystem restoration and it accomplishes this through supporting communication among members and in promoting topics and resources that are valid and useful in restoring the ecological function of degraded areas.

Ecology and control of plant invasions

T09-P01 - Invasiveness of the non native species *Terminalia catappa* (Combretaceae) in a protected area in southern Brazil

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Invasive non-native species are one of the greatest threats to biodiversity and to the provision of ecosystem services. On a local scale, the assessment of colonization rates and of establishment of new populations is fundamental for the development of management strategies. In this study, we assessed abundance and population structure of *Terminalia catappa* in a coastal sand dune ecosystem (restinga) located in the Carijós Ecological Station (Daniela beach, Florianópolis / SC), before and four years after management interventions. The management interventions consisted in the elimination of all individuals which were visually identified through mechanical control of juveniles (up to 100 cm high) or mechanical control associated with chemical control of the others (> 100 cm high). The censuses were carried out in 2011 and 2014/2015. In 2011, 81 plants of *T. catappa* were recorded. The majority of them (59.2%) were juveniles (101-300 cm high), and just three of them (3.7%) were adults (bearing fruits), indicating the beginning of the process of establishment of the species in the area. In 2014/2015, 79 individuals were registered, with no signs of reproduction. About 71% of the plants were seedlings and juveniles (up to 200cm in height), evidencing the high recruitment potential of the species. This study highlights the potential of establishment of *T. catappa* in restingas. The management of the species must be focused on control interventions in the area and in the surroundings, and on regulations on the species use and on fostering of native species for landscaping purposes.

T09-P02 - Rehabilitation of alien invaded riparian zones and catchments using indigenous trees: An assessment of indigenous tree water-use

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Trees can be used for catchment rehabilitation and riparian zone management. The impact of expanding rehabilitation programs using indigenous trees is of critical importance in a water scarce country. The question then is whether these indigenous species use less water than the fast-growing invader stands? Water-use within a riparian forest along the Buffeljags River in the Western Cape of South Africa was monitored over a three year period. The site consisted of an indigenous stand of Western Cape afrotemperate forest adjacent to a large stand of introduced *Acacia mearnsii*. The heat ratio sap flow technique measured the water use of a selection of representative indigenous species in the indigenous stand and *A. mearnsii* trees in the alien stand. The indigenous trees showed significant intraspecific differences in sap flow rates, varying from 15 to 32 L·day⁻¹ in summer. In winter (June) this was reduced to 7 L·day⁻¹ when there was less available energy for transpiration. The combined accumulated daily sap flow per year for the *Vepris lanceolata* and *A. mearnsii* trees was 5 700 and 9 200 L respectively, demonstrating the higher water-use of the *Acacia* trees during the winter. After spatially upscaling the findings, it was concluded that the alien stand used six times more water than the indigenous stand, showing that there would be a significant hydrological gain if the alien species are removed from riparian forests and rehabilitated back to their natural state.

T09-P03 – Population projection matrix of a native shrub and an invasive grass: Implications for ecological restoration in the Cerrado

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Population dynamics studies can indicate demographic processes affecting the populations' persistence in restoration areas. African grass invasions represent a major challenge to Cerrado restoration. We studied population dynamics of a native shrub (*Lepidaploa aurea*) with high establishment rates and an invasive grass (*Urochloa decumbens*), in restoration areas which were previously dominated by *U. decumbens*. Areas were burned and plowed before direct seeding for restoration purposes. We studied populations of *L. aurea* established through direct sowing on their 2nd, 3th and 4th year, considering also a 2nd year population under *U. decumbens* dominance. We studied the invasive grass in a dominant and a non-dominant population (under *L. aurea* dominance) to understand how these species affect each other. Despite high establishment and fast growth, *L. aurea* population growth rates decline over time ($\lambda_{2nd} = 1.032$, $\lambda_{3th} = 0.690$ and $\lambda_{4th} = 0.618$), it also declines in response to *U. decumbens* dominance ($\lambda_{2nd-non-dominant} = 0.803$). Even after strong disturbance for soil preparation, the invasive grass populations were reestablished (26-24 individuals/m²) and had projected population growth rates varying from 0.705 to 0.723. Survival of large individuals was the most important vital rate for population growth of the two species. Our data indicate the need for continuous management and control of *U. decumbens*, and likely other African grasses, even in restoration areas where native species had high establishment success. Especially since we identified that *U. decumbens* significantly decrease the native shrub growth rates but was not affected by the dominance of native shrubs.

T09-P04 – When inaction is not an option – Disturbance maintains grassland biodiversity in the face of widespread invasion by exotic forage grasses.

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Temperate grasslands have been prone to invasion by alien plant species. Removal of livestock grazing has been advocated to enhance restoration of native plant communities. Paradoxically, long-term protection of grassland has compounded this pattern by favoring dominance by highly competitive grass species. Here we evaluate mowing as a management tool to prevent exotic grass invasion, and for restoring native grass assemblages after removal of livestock grazing. We further compared composition and diversity of ungrazed mowed grassland to that of seasonally grazed grassland. The study was conducted in the Flooding Pampa, Buenos Aires, Argentina. In 2004, we established 6 grazing exclosures, which were heavily dominated by the pasture grass *Festuca arundinacea*. In 2014, we started a mowing treatment applied three times per year in each of 6 plots, adjacent to unmowed plots. For two years, relative cover and biomass of native and exotic species were monitored in ungrazed, mowed and grazed grassland. The proportional contribution of native species to total richness was equal across treatments. However, relative native biomass was 60% and 19% greater in grazed and mowed grassland, compared to fenced grassland, respectively. Grazing and mowing increased community evenness (27%, and 15%, respectively), relative to exclosures. This reflected the larger contribution of native grasses under grazing (30%) and mowing (4%). Our results show that, at present, domestic grazing is a valid option for precluding widespread dominance by exotic grasses and for biodiversity conservation. A mowing regimen might be useful to recover native grass communities only in the longer term.

T09-P05 - Natural regeneration in bamboo dominated forest remnant submitted to herbicide control treatment in the Pampa Biome, South Brazil

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The present study aimed to analyze the natural regeneration of the Deciduous Seasonal Forest in bamboo-dominated areas (*Bambusa tuldooides* Munro) submitted to chemical control. We evaluated the natural regeneration in 80 plots of 1 m² six months after herbicide application (Tibutiuron; 30 kg ha⁻¹) in December 2015. We also evaluated the phytosanitary state in natural regeneration, using the visual scale methodology from 1 to 4 (1 light damage and 4 severe damage). We considered all individuals with height from 30cm to 1.30m and calculated Shannon diversity index (H') and Berger-Parker dominance (D). We sampled 40 individuals distributed in 14 species. The most abundant species were *Myrsine umbellata* Mart (6); *Cupania vernalis* Cambess (4); *Ocotea pulchella* (Nees) Mez (3). These species are tolerant to shade, which may explain their successful development in the bamboo-dominated area. The phytosanitary status of natural regeneration did not show high levels of damage. The values for H' and D were, respectively, 2.11 and 0.37, so low diversity and dominance may be considered. We concluded that the most abundant species observed could be key-species in restoration strategies to bamboo-dominated forests.

T09-P06 - Canopy shade and litter stock thresholds for invasive grasses inhibition in different restoration systems

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One of the major challenges in restoring degraded ecosystems is the control of invasive species. In tropical forests, soil litter might act as a physical barrier, and the canopy shading might decrease light availability, preventing the developing of invasive grasses. We aimed at determining canopy shading and soil litter stock thresholds for inhibiting the development of invasive grasses in restored seasonal tropical forests. We sampled nine 50 x 50 m plots, distributed along three restoration systems: agroforestry, high diversity, and direct seeding, in an area of seasonal semideciduous tropical forest in Botucatu - SP, Brazil (Atlantic Forest). Two parallel transects were established per plot, where we sampled *Panicum maximum* shoot biomass and soil litter stock, and measured the Photosynthetically Active Radiation intercepted by the canopy -IPAR in three subplots of 0.25 m². The sampling was done during the dry season, where canopy cover is minimum, due to partial leaf shedding of canopy trees. Data were analyzed by multiple regression and ANOVA. Grass biomass decreased significantly with canopy cover levels over 80% (20% IPAR) and litter accumulation between 1,6 kg m⁻² and 2,0 kg m⁻². Although no difference in soil litter stock was found between restoration systems, the direct seeding system had higher PAR levels due to lower canopy cover (58.9%). A quick development of a dense canopy with high litter production and accumulation by the planted species is desirable where invasive grasses are hindering forest natural regeneration.

T09-P07 - Managing African grasses on Cerrado for its restoration: Relationships between fire intensity and invasives

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Invasive grasses are one of the most difficult biological filters to overcome on the restoration of Cerrado. They can alter the micro-habitat, hindering mostly the recovery of the herbaceous layer, but also jeopardizing the recruitment of shrubs and trees as well. Among the management techniques that could be used to control them, prescribed burnings are being tested as one possibility. Therefore, we aimed to study the effects of fire, mostly of fire intensity, on the recovery of the invasive African grasses *Melinis minutiflora* and *Urochloa brizantha*. We evaluated fire intensity of 16 plots (15x15m) during prescribed burnings

in three seasons in 2014; and collected the biomass of invasive grasses before and two years after fire. We conducted a linear regression to investigate the relationship between fire intensity and recovery of the invasive grasses, using the log difference of their biomass in 2016 and in 2014 as response variable. We found no relationship between fire intensity and invasive species regeneration after fire, either considering both together ($p=0.80$, $r^2=0.003$) or individually for *M. minutiflora* ($p=0.91$, $r^2=0.001$) and *U. brizantha* ($p=0.99$, $r^2=3.378e-06$). Moreover, we found correlation coefficients with values approximately equal to zero, indicating that fire intensity itself is not a factor determining the invasive grasses responses. Thus, other factors than fire might be affecting invasives' recovery after burning, such as grass phenology and precipitation.

T09-P08 - Occurrence and impacts of non-native species in restored areas of rupestrian grasslands

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Invasion of non-native plant species in restored areas represents a major problem for restoration efforts. These species can result in the failure of the restoration process, the loss of native species and economic, social and cultural damages. We aimed to describe, for the first time, the density and distribution of non-native plant species to assess their impact in restored areas of rupestrian grasslands along the MG-010 highway in the Espinhaço mountain range, Minas Gerais, Brazil. More than 60 non-native species were found to be established in the region, many with a high propagating potential and with the ability to suppress native vegetation. These species appeared mainly since the paving works of the highway, about 20 years ago. Among the species found, *Andropogon gayanus*, *Leucaena leucocephala*, *Melinis minutiflora*, *Mimosa pigra*, *Paspalum notatum*, *Urochloa brizantha*, *Vernonanthura phosphorica* and *Waltheria indica* showed wide distribution along and high density at each sampling point. Establishment of these species may be related to the limestone addition to the soil during the road preparation, improving its nutritional content. Additionally, attempts to restore such environments also included the use of exotic species. Moreover, some of the species found are highly associated with livestock, and their propagules are initially dispersed by cars and trucks which pass through the area. The absence of monitoring and management programs of the restored areas could be another factor which results in failures of the restoration efforts, endangering the entire local biota.

T09-P09 - Impacts of the invasive non-native tree *Terminalia catappa* on coastal scrub regeneration in Florianópolis, southern Brazil

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Invasive non-native species are among the main threats to biodiversity worldwide. They can alter the structure and composition of plant communities, impact natural regeneration and, in some cases, change successional trajectories. Coastal scrub (restinga) is one of the most highly fragmented ecosystems in the Atlantic Forest biome. Habitat loss and invasion by non-native species are cited as some of the main causes of impacts to coastal scrubs. The objective of our work was to assess the effect of *T. catappa* on restinga regeneration on frontal dunes of Daniela Beach, Florianópolis, Brazil. We hypothesized that there are differences in richness, diversity and composition of indigenous species regenerating under the crowns of *T. catappa* trees compared to sites where the species was not present. All regenerating plants (20 - 100 cm height) were identified and counted in four subplots established underneath the crowns of 20 *T. catappa* trees. Four control subplots were installed on sites at least five meters away from each *T. catappa* tree included in the assessment. Both abundance and richness of native plants were lower under *T. catappa* crowns than in the adjacent control areas. Additionally, species composition differed between the two conditions. Some shrubs such as *Baccharis dracunculifolia*, *Baccharis singularis* and *Myrsine venosa* were found exclusively under *T. catappa* crowns, which may represent a significant change in the structure of coastal scrub formations. Understanding the impacts of introduced species on natural regeneration is important to help defining practical restoration measures for coastal ecosystems.

T09-P10 - Control of invasive Myrtaceae, *Ugni molinae*, at Robinson Crusoe Island in Chile

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The invasion of alien species is one of the most important causes for biodiversity loss and a serious threat to ecosystems. Its consequences are severe in oceanic islands as they are the main factor increasing the rate of species extinction. In the Juan Fernández Archipelago, the alien plant species have altered the islands ecosystems leaving 29 plant species in a critical state of conservation. *Ugni molinae* is an invader that in 2010 covered 119.4 ha of Robinson Crusoe Island (2.5%) with an annual expansion of 1 ha. In order to contribute to the ecosystem restoration, in 2013 we established an essay to assess the chemical control of *U. molinae* at Robinson Crusoe Island, using two herbicides: Triclopyr and Metsulfuron-methyl, applied by following two methods: Re-sprout spraying and stump contact; and two doses. Also, mechanical methods were assessed using a plastic sheet for weed control. The essay was monitored a year after the control methods were applied. The methods that showed a better performance were those with the plastic sheet and those were Metsulfuron-methyl was applied.

T09-P11 - Forest regeneration in mechanical control area of bamboos

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Exotic bamboos when inserted in natural areas may lead to direct competition for the development of native species. We tested the mechanical control to control *Bambusa tuldooides* Munro in Deciduous Seasonal Forest, under the dominion of the species, in the state of Rio Grande do Sul, extreme south of Brazil. The work was developed in 2015, using a crawler tractor, with removal of the stalks below the ground and drag in 150 m². After six months, we counted and identified the individuals with height between 30 and 130 cm present in the natural regeneration, in 80 subplots (1 m²), and we calculated the diversity index of Shannon (H'). Natural regeneration had 194 individuals, 13 species and H' = 1.77. Asteraceae and Solanaceae were the most representative families. The most abundant species were *Solanum mauritianum* Scop. Voucher. and *Solanum viarum* Dunal., typical of open and anthropized environments. It was concluded that the drag was efficient to initiate natural regeneration. Despite this, there should be continuous monitoring of the area due to the possibility of regrowth of bamboos and increase of erosive processes.

T09-P12 - Control of *Urochloa decumbens* with native legumes and plastic cover in ecological restoration area in riparian forest

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The control of exotic species represent a challenge in the areas that are under ecological restoration process. This work aims to evaluate practices to control exotic grass, using cover plants and plastic coverage. The study was carried out in central Brazil, an area in process of restoration since December 2011. The experimental design was randomized complete block in a factorial (4 types of treatments x 2 times), with three replications. The treatments were installed in two periods - March-August 2013 (1st) and December 2013 to May 2014 (2nd) - as follows: T1 - planting seedlings of *Arachis pintoi* cultivar 'Amarillo'; T2 - plastic coverage (1.20 m x 2 m); T3 - broadcast sowing of seed mixed of *Stylosanthes* spp. cultivar 'Campo Grande' (80% of *Stylosanthes capitata* and 20% of *Stylosanthes macrocephala*) and T4 - control. These species are important because both are native and have developed the seed production system. We used analysis of variance (ANOVA) and Tukey's test at 5% significance level. In the first period, there were no significant differences in grass cover among treatments, except for control, which was higher (88.85%). In the second period, the treatments differed among themselves, with less grass cover in plastic coverage (11.65%) and *Stylosanthes* spp. cultivar 'Campo Grande' (19%). The plastic coverage and *estilosantes* were the most efficient treatments for the control of grass, regardless of period. Native species with potential for the control of aggressive alien species can assist the ecological restoration.

Economic aspects of ecological restoration

T03-P01 - Economic aspects of restoration policy in Brazil: An ex-post assessment at sub-national level

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Brazil has announced an ambitious goal of restoring 12 million hectares. To direct this efforts the federal government recently launched the National Plan and Policy for Recovery of Native Vegetation (PLANAVEG & PROVEG). The present study aims contributes to weigh strong and weak elements of the new federal regulations, through an ex post assessment at state level, to evaluate the effectiveness of state governments in the implementation of restoration policies. Focused on governance and economic aspects of restoration in the decade prior to ratification of the Paris Agreement, we try to demonstrate what had been done by the state policies to restore and increase land cover. To perform the analysis was used investment data of subnational governments on restoration policies, this financial data was used together with data on the institutional capacity of state environmental agencies, the capacity of production of inputs for reforestation, among others, each one linked to strategies developed by the PLANAVEG. Information from federal and state government databases was cross-checked with information from non-governmental organizations monitoring deforestation and afforestation. The Data Envelopment Analysis (DEA) tool was used to processes information, and determine the efficiency of government to increase forest cover through restoration. Our results highlight the size of the effort made to restore land degraded over the last 10 years. The results suggest the efforts in most states are much smaller than necessary, and insufficient to meet established targets, and there is evidence of inefficiency in the application of public resources for restoration.

T03-P02 - Studies on restoration of riparian forests: contributing with public policies and environmental legislation of Brazil

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Ecological restoration is a strategy that results from the quest for a balance between biodiversity conservation and agricultural production, although there are knowledge gaps to be overcome before this perspective becomes efficient and in large scale. The objectives of these studies, part of the second module of a thematic project are: 1) to test restoration methods, considering the development of ecological functions by riparian vegetation of different widths, meeting the scientific demand of the new Brazilian Forest Code. These studies are being developed in rural properties owned by Usina São João (USJ) and Usina São Manuel (USM), where 5,400 and 11,200 seedlings were planted, respectively, to restore the riparian vegetation ranging 15, 30 and 50 m width area. In USJ, the survival rate was approximately 70%, and it was 30% in USM. For the clayey soils in USJ, there was no considerable deposition of sediments in the riparian vegetation, independently of the width used. The laminar erosion was a dominant process. For the sandy soils in USM, there was higher deposition in areas covered by spontaneous vegetation, followed by the 15 m wide riparian forest area; 2) investigate alternatives for cost reduction, once restoration is mandatory to any landowner according to the new legislation. Some studies are linked to this objective, for example, one that demonstrates that direct seeding of fast growing native species associated with green manure species can be considered effective since they result in high density of individuals and low costs, compared to planting seedlings. FAPESP: Grant#2013/50718-5.

T03-P03 - Economic analysis of forest restoration for compliance with the Forest Code

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The Brazilian Forest Code, in line with the Brazilian NDCs, created the largest forest restoration agenda in Brazil by requiring the conservation of native vegetation in private areas. Our study seeks to support public and private policies to guide large-scale forest restoration strategies by assessing the costs of three different forest restoration techniques by hectare, for eight states in Brazil, taking into account their operational costs with the producer carrying out the activity. Our analyses were based on the applicability of each technique, according to 3 natural regeneration potentials and 6 physical-environmental conditions (combinations between precipitation and declivity levels). Results demonstrate that the lower the declivity level is, the cheaper the restoration gets. Around 80% of the analyzed regions has until 12% of declivity, thus, has the lowest costs. From low to high slopes, the Natural regeneration costs range from US\$275/ha to US\$1.176/ha, showing up as the least costly between all the techniques. The Direct sowing costs, evaluated just for low declivity areas, varies between US\$751/ha to US\$1.149/ha. The Direct planting presented the highest costs, from US\$2.576/ha to US\$5.587/ha, even though it's the most disseminated technique nowadays. We also assessed returns (IRR) of forest restoration for economic purposes (timber), which range from 6.2 to 12.7% in an optimistic price and yield scenario, indicating better estimates are necessary. We conclude that forest restoration costs are still very high in Brazil, mainly due to weak demand and poor coordination of the restoration chain.

T03-P04 - Eucalyptus paying the bill for the restoration of the Atlantic Forest

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Paying for the costs of ecological restoration is still a major challenge. Here, we investigate the potential of exotic Eucalyptus intercropped with native trees, during the first years of tropical forest restoration plantations, to serve as an "economic nurse crop" and counterbalance the costs of restoration. We performed an economic analysis based on net present value (NPV) of a tropical forest restoration experiment implemented in Aracruz, ES, Brazil. We compared traditional restoration, Eucalyptus monoculture and a mixed forest using a 1:1 proportion between native trees and Eucalyptus. The same silvicultural treatments were applied to all plots and rotation age was established as 5 years. We used the real wood volume produced in the experiment and the regional costs of implementation, harvesting, transportation and also the local round wood price to simulate different restoration scenarios. We analyzed the NPV for traditional restoration and alternative restoration with and without enough natural regeneration to replace Eucalyptus, and the consequent need to plant native trees seedlings after Eucalyptus is removed, considering from one to three rotations. We found that the income from Eucalyptus exploitation in our alternative restoration models can pay for as much as 51-92% of restoration costs. The best scenario consists of three rotations of Eucalyptus and abundant natural regeneration to replace the gaps after the last harvest. We conclude that the transient use of Eucalyptus as an economic nurse crop can overcome the economic barrier posed to large-scale restoration in the tropics. Grant #2016/07498-2, São Paulo Research Foundation (FAPESP).

T03-P05 - Economic feasibility of Amazon Forest restoration: a spatial analysis of potential carbon capture service

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Peru is an allied country to meet the 20x20 Initiative, with the potential contribution of 3.2 million hectares of degraded ecosystems restored. For this end, the Degraded Areas National Program is being formulated, led by Agriculture Ministry (MINAGRI), which is in design and viability phase, in parallel with experimental pilots emphasizing on climate change mitigation.

Before taking any action, an assessment on forest restoration feasibility is needed to a) address the main forest degradation drivers, b) to determine the most appropriate restoration scheme and c) to order the implementation of national initiatives. To achieve the assessment, it is analyzed how attractive forest restoration is to direct users from a basic economics approach, backed with the cost-benefit analysis. Based on the use of GIS, eligibility scenarios for forest restoration are constructed and mapped, valuing the carbon capture service as a reference for economic analyzes. Preliminary results indicate that the alternative closer to compensate the forest change value is that of passive forest restoration, and that is more suitable to areas distant to market fluxes (populated centers, main roads and river lines). On the other hand, implementing active forest restoration means high transaction costs, resulting in a not too attractive compensation alternative for the forest degrading agent since these scenarios appear to be closer to market fluxes.

Ecosystem services and natural capital

T13-P01 - Ecological restoration of *Fitzroya cupressoides* (endangered conifer): contribution to the ecosystem biodiversity and carbon stock

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Fitzroya cupressoides is one of the most long-lived species, threatened and endemic to the temperate rainforests of Chile and Argentina, subjected to a long history of exploitation, just a few fragments smaller than 2 ha remaining in the Central Depression. We started a long-term ecological restoration project in 1998 aimed to genetic conservation of the species, to verify how the ecological restoration of *Fitzroya* populations could contribute to biodiversity and carbon storage to the ecosystem. We established seven 0.1 ha permanent plots in 41° 25' S, 73° 08' W in different conditions, including: three plots in a stand under restoration (RA), planted with *Fitzroya* seedlings in 1998, and one plot in each of the following conditions: 120-year old *Fitzroya* stand, broadleaved evergreen stands with and without grazing, and grassland. Seedlings survival and growth of *Fitzroya*, besides cover and richness understory, density and aboveground biomass were assessed. We found successful establishment of *Fitzroya* in RA (survival 73%, average height 251.8 cm ± 5.2 cm). Species richness in RA was similar to the other stands (25 spp. and 22-24 spp. of vascular plants, respectively). Biomass in living trees was 23.4 -82 Mg/ha in RA, compared to 185 Mg/ha in *Fitzroya* stand. Ecological restoration resulted also in carbon storage in the understory, since it was higher in RA (3 Mg C/ha) than in the others conditions (<0,6 Mg C/ha). The restoration intervention oriented to genetic conservation of an endangered species provided habitat for native non-arboreal species, besides contributing for carbon storage, biodiversity and cover understory.

T13-P02 - Assessing the hydrological regime in Harman and Prejmer Marshes

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This research is located in two Natura 2000 sites, areas in which a LIFE project founded by the EU has been implemented (2012-2017). The aim of the study is to determine the hydrological dynamics of groundwater in the marsh area and to characterize the hydrological regime of the soil. In order to intervene for ecological reconstruction of the Harman and Prejmer marshes, direction and speed of the groundwater flow was established, likewise the dynamics of groundwater level and scenarios solutions were built. Topographical surveys were carried out: gullies, ditches natural drilling and micro relief for the investigated area. Groundwater level and their dynamics were determined through 12 wells in Harman and 27 in Prejmer (organized in 6 hydrological study units), while for measuring meteorological elements a permanent weather station was installed. The results showed that groundwater flow direction is from southwest to northeast and water accumulation occurs in the northeastern part of the modeled area. While in 2014 - 2016 the groundwater level has changed due to both rainfall and warming, we did not see changes in hydrological conditions. Moreover the results of the hydrological regime showed that areas where the species and habitats are not performing well do not have an accessible distance from the surface to the ground water level. Assessing the changes in the water regime over 5 year period has contributed in determining the areas where concrete actions needed to be implemented, in order to raise the water level and to improve marsh habitat quality.

T13-P03 - Management of the mountain ranges based on the characteristics of cold air

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Cold air develops at negative radiation balance of the surface during calm nights. With its lower temperature than the surrounding air, local cold air has the positive aspects of a decrease in air temperature. Hence, mountains as important areas of cold air production should be conserved. However, they are becoming increasingly damaged due to development. This study aims to analyze the properties of cold air production and its flow off of mountain ranges, and to suggest management and restoration strategies that enhance air conditioning functions of mountain ranges. For this purpose, three study sites were selected including mountains in Busan (Gudeoksan), Ulsan (Goheonsan), and Pohang (Unjusan) in South Korea. We analyzed cold air flow and its height at the three study sites based on topographic properties and land use. We also analyze how they change by the development. The cold air produced in the vicinity of Gudeoksan was not fully developed because of the high-density urban development at the border of mountain. In order to enhance air conditioning functions, strict conservation policies are required and efficient restoration plans for damaged mountains should be also established.

T13-P04 - Biomass carbon storage of desert grassland on the edge of Tengger Desert, Northern China

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Accurate estimation of biomass carbon storage is of great significance in evaluation the role of desert grassland in regulating desert ecosystem carbon cycling, guiding the construction of ecological restoration and mitigating global climate change. Desert grasslands with high diversity are widely distributed in the south fringe of the Tengger Desert, China. Which is an ideal area to study biomass carbon density. Large-scale field investigations and sampling were carried out, a total of 1200 shrub plots and 1200 grass plots were set up. The results showed that biomass carbon densities of the leaves, new branches, aging branches, standing-dead material, aboveground biomass of shrubs and shrub roots in study area were 8.39 g m⁻², 4.53 g m⁻², 31.34g m⁻², 11.05 g m⁻², 55.31 g m⁻² and 66.23 g m⁻², respectively. The carbon densities of the aboveground, root and total biomass of herbaceous plants are 7.15 g m⁻², 73.68 g m⁻² and 80.82 g m⁻², respectively. Above- and belowground biomass carbon storage of desert grassland in the south fringe of the Tengger Desert, China is 4.59 and 9.07 Tg, respectively. Our results indicated that there were significant differences in biomass carbon density between vegetation communities. Combined biomass organic carbon density of specific community and the corresponding community area may greatly increase the accuracy of estimation of organic carbon storage in desert grassland. Based on these results, the appropriate vegetation types can be selected when reconstructing vegetation for seriously degraded desert grassland in arid and semiarid areas. Moreover, we can more accurately assess the carbon sequestration potential of restored vegetation.

T13-P05 - Opportunities for carbon credits generation through forest restoration projects in areas of influence and protection of the right bank of the reservoir of Itaipu Binacional hydroelectric power station

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Generation of electric energy with social and environmental responsibility is the challenge of hydroelectric power plants worldwide. Mechanisms that contribute to improving the people's quality of life, conserving nature and mitigating the effects of climate change represent an unprecedented opportunity for hydroelectric companies and their areas of influence. We evaluated real possibilities of implementing restoration projects with voluntary forest carbon standards and collateral benefits in areas of influence and protection of Itaipu Binacional hydroelectric power plant on the right bank of Parana river.

We used the Gold Standard Certification Scheme, as a reference, to conduct the analysis, which includes certification of collateral benefits. Data from one restoration project with native forest species in the paraguayan buffer zone of the reservoir (Itaipu Preserva) and another project for restoration of biological corridors with native and fast growing species in the Atlantic Forest

(Paraguay Biodiversidad) were used. Our results indicate that the total emission reduction is 794,138.9 tCO₂e due to Itaipu Preserva (2,469 ha) and 212,686.3 tCO₂e due to Paraguay Biodiversidad (374 ha). The total from sale of carbon credits from both projects would be US \$ 6,042,956 with an average price of US \$ 8.5 / tCO₂e. Considering the certification costs, net income would be US \$ 5,726,668. These results suggest a good opportunity for initiatives in voluntary carbon credits markets for Itaipu Binacional and other hydropower plants that promote sustainable development at the regional level.

T13-P06 - Carbon stocks on forest floor litter and dead wood in degraded tropical forests of southern Mexico

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Biomass accumulation in tropical forests plays a key role in global carbon cycle. In this study, we quantified carbon stocks in litter and dead wood in four forest successional-stages: 5 years, 10 years, 20 years and primary forest, located in Calakmul Biosphere Reserve, southeastern Mexico. Litter and deadwood were sampled in 23 carbon monitoring plots across four successional phases. Forest floor litter was sampled in four random subplots of 0.25 m² within the monitoring plots. Dead wood of 10-15 cm diameter were sampled using the line intersect method in four 25-meter straight lines moving outward from each corner of the monitoring plot (1000 m²). We found significant differences ($p < 0.05$) in litter and dead wood carbon stocks among successional stages. The values of carbon stocks in litter was higher in mature forests with 6.7 MgCha⁻¹, followed by forests of 20 years with 5.9 MgCha⁻¹, forest of 5 years with 4.3 MgCha⁻¹ and finally forests of 10 years with 4.1 MgCha⁻¹. The values of carbon stocks in dead wood were of 36.6 MgCha⁻¹ in primary forests, 23.3 MgCha⁻¹ in forests of 5 years, 21.0 MgCha⁻¹ in 20 year forests and 11.7 MgCha⁻¹ in 10 year forest. We also observed that carbon stocks increases gradually with forest age. We found that the secondary forests recover its carbon stocks within about 20 years after abandonment of slash and burn agriculture. These results are important to take in to consideration the dynamic processes and functioning of forest succession.

T13-P07 - How important are roots to biomass quantification in early stages of restoration? Field measurements in a Coastal-plain-forest restoration area: a case study

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Biomass estimation is relevant to ecological restoration in order to evaluate the state of the restored ecosystems and the success of restoration programs. Furthermore, planting seedlings can be used as a carbon mitigation tool. The study of biomass has increased markedly in the last three decades; however, two big lacks of information remain: the quantification of belowground components and this of young mixed forest plantations. Therefore, we aimed to (i) adjust a good model for local biomass estimation, (ii) quantify roots contribution to total biomass and (iii) estimate the biomass stored in the first two years after planting. We quantified dry weight of leaves, woody parts and roots in 61 seedlings of 21 species. We also measured diameter at soil height (DAS), height (H) and crown projection of the 61 collected and 1434 monitored seedlings in a two-year Coastal-plain-sand-forest restoration area in Caraguatatuba, SP, SE Brazil. We adjusted models by simple linear regression using R², Syx, p-values and residues distribution as model selection criteria. Selected models were: $\ln(\text{BMT}) = -0.25 + 0.82 \ln(\text{DAS}^2 * \text{H})$ ($R^2 = 0.94$; $\text{Syx} = 0.55$; $p < 0.0001$) to total biomass and $\ln(\text{BMA}) = -0.78 + 0.85 \ln(\text{DAS}^2 * \text{H})$ ($R^2 = 0.92$; $\text{Syx} = 0.64$; $p < 0.0001$) to aboveground biomass estimation. Total biomass was 49.735 Mg.ha⁻¹, 29% of which was stored in belowground components. This result reinforces the importance of considering roots in biomass estimation, especially in early stages of restoration. Our results also suggest that mixed tropical forest restoration can be a relevant carbon sink since large amounts of biomass are stored even in early stages of restoration.

T13-P08 - Forest restoration in Amazonia: Carbon sequestration, biomass allocation and nutrient constraints of the Fabaceae tree species

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To understand the biomass growth rates and carbon sequestration of six important Fabaceae tree species, a field study was conducted in a degraded area of the Balbina Hydroelectric Dam Forest Restoration Program (PRAD Balbina) in President Figueiredo, AM, Brazil. To evaluate the nutrient constraints of the site, half of the plants were fertilized (T2) while the others remained unfertilized (T1). Following IPCC guidelines, the six species in the T2 treatment had a mean annual biomass production of 20.5 Mg ha⁻¹ year⁻¹. The fast-growing *Clitoria fairchildiana*, *Inga edulis* and *Acacia mangium* species had an annual biomass production of 36.6 Mg ha⁻¹ year⁻¹. Plants in the T1 treatment allocated more biomass to root production and had a biomass production of approximately 0.0 Mg ha⁻¹ year⁻¹. After two years, the forest restoration plantation stocked 17.8 Mg C ha⁻¹ in all portions of the plant biomass, including roots, and 33.8 Mg C ha⁻¹ was stocked in the fast-growing species in the fertilized treatments. The short-lived (fast-growing) species can provide ecological services such as shading, C and nutrient build-up, natural regeneration and reestablishment. The long-lived species *Cenostigma tocantinum* and *Dipteryx odorata* will provide long-term C stock and biodiversity. All the species studied can be used for ecological and/or commercial purposes, except *Senna reticulatta*, which did not exhibit satisfactory development, especially during the 2015/16 El Niño event. The tropical species exhibited considerable growth in biomass and C storage and therefore showed a great capacity to mitigate climate changes in forest restoration of degraded areas in Amazonia.

T13-P09 - Proposal of techniques for the revitalization of stretches of urban streams with concrete beds in Sorocaba (SP-Brazil)

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In Brazil, the execution of projects aiming to rehabilitate urban – especially concreted – streams is still in its early stages, even though they are often found in cities. The outcomes of an ongoing project developed to create and evaluate low-cost and ecologically appropriate landscape alternatives to recover watercourses will be presented. The project has been conducted in stretches of small, concreted streams located in Sorocaba, Brazil. The hydrological and water quality data collected during the first phase of the project revealed that the stretches are in different levels of degradation on the basis of organic matter concentration and sediment deposition. The second phase of the project, regarding restoration interventions, has begun recently. In one of the stretches, a set of five jute bags filled with 26 kg of construction gravel was installed with the purpose of reestablish the bottom of the river and provide a substrate for installation of plants and invertebrates. In the second stretch, the stream channel was sectioned in steps, automatically re-oxygenating water and retaining sediments. Besides, biodegradable 6.5 m x 13 cm rolls, filled with 35 kg of construction gravel, were installed parallel to the water flow, to retain organic material and to provide substrates. In the third stretch, a geosynthetic lining system for drainage transversal roll, filled with 40 kg of gravel was installed, aiming to retain organic material. The project is now on its third phase, and results can be already noticed, such as oxygen level increase, resulting from the small dam created, and the return of aquatic plants and some larvae.

T13-P10 - Restoration of the Rimac River ribers in the city of Chosica, Lurigancho district, Lima, Peru, for climate risk management

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The city of Chosica is located in the middle basin of the Rimac River, at 850 masl. It has an approximate population of 300 thousand inhabitants. Historically, the district has lost important cultivated areas located on the banks of the Rímac River that have been occupied by houses and industrial zones. Due to its geographic location and physiography, this district is one of the

most affected by rainfall, which in the rainy season generates mud flows and debris (huaycos) that converge to the Rímac river through its multiple small gorges. With extreme events such as El Niño, discharges increase significantly resulting in significant infrastructure and human life losses. This year (2017) El Niño has affected a considerable number of families and homes. It is anticipated that in the next few years the problem could be reintroduced. Many sections of the river bank in the district are illegally occupied, degraded and without original vegetation cover, with consequent processes of erosion of particles and masses. The urban restoration project proposes zoning, recovery of degraded areas, soil conservation, revegetation and reforestation, which involve the use of green and gray infrastructure, reducing rainfall and river impact, improving rain infiltration and controlling the increase of river flows with the application of scientific knowledge of river geomorphology and in accordance with the new forestry and wildlife legislation that promotes urban forestry for the purpose of recovering degraded areas with the participation of regional, local governments and the private sector.

Ethics and Values (Philosophical aspects of restoration)

T06-P01 - Preserving historic cultural landscapes and restoring ecosystems in the USA: A comparative history in timelines

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This poster presents a brief history of cultural landscape preservation and ecological restoration in the United States in the form of two parallel timelines. Both fields began to coalesce as modern practices during the late nineteenth century, began to institutionalize during the first half of the twentieth century, and emerged as full-fledged professions during the late twentieth century. In many ways the fields of ecological restoration and historic preservation have wrestled with different strains of the same fundamental questions: How do landscapes evolve through time, and what dynamics of natural and human systems converge in that evolution? How do we know for certain what historic conditions were truly like, and is an authentic restoration possible? Even if it is technically possible to accurately restore a particular environment, does that necessarily mean we should? Despite grappling with parallel, unremitting problems, the practices of conserving nature and culture in landscapes have largely followed separate yet parallel trajectories. Occasionally they have joined in fruitful collaborations, while at other times they have clashed. The timeline will highlight these moments, along with recent innovative and productive collaborations that have emerged among ecologists and scholars in the humanities. When viewed retrospectively and in tandem via the graphical device of a comparative timeline—these parallel histories suggest the wealth of knowledge and experience that each field offers the other, and provide a foundation upon which to advance collaborative working relationships among ecologists and historic preservationists.

T06-P02 - Participatory governance for ecological restoration in family farms in Southern Brazil

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This Project developed ecological restoration actions in family farms located in the municipality of Governador Celso Ramos along the Areias River which is located inside the Environmental Protection Area of Anhatomirim, a federal protected area. The innovative aspects were the governance process and the restoration techniques used. The actions took place through a process of participatory governance with the integration among public, private and community sectors, promoting the exchange of experiences and knowledge for the construction of an environmental awareness, in order to offer care with the land, the community and the river. Joint efforts carried out the interventions for restoration, which have proven to be an excellent way to carry out restorations process at low costs as well as engage those involved and approach the community, even those who were initially uninterested. These actions had active participation and involvement of the local community, the local schoolchildren, neighbourhood associations, researchers and civil servants from the Town Hall and from the environmental agency. The techniques used were inspired on nucleation techniques and ecologically based Agroforestry Systems with the formation of high diversity plant beds with densified planting of native trees and adult cuttings. The plant beds were built with the soil of the excavation of the swales and weirs, which has varied sizes and shapes, creating an interconnected network of redistribution and enrichment of the water. It was also applied the pruning for roots strengthening and obtainment of branches and organic material for soil cover layer. The restoration was implemented in a small scale, just half hectare, but we are still working to gain scale and restore all the riparian forest of the Areias River.

Fauna: ecological aspects

T11-P01 - Habitat selection and population control of feral goats to restore an oceanic island of the South Pacific

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Feral goats (*Capra hircus*) are among the most destructive exotic herbivores on oceanic islands. They are present on the Alejandro Selkirk Island (ASI, which forms part of the Juan Fernandez archipelago, Chile), consuming many native plant species and hence causing severe soil erosion. The control of invasive herbivores on islands is key to aid in the recovery of native vegetation and to prevent extinction and co-extinction events. Without an urgent intervention, not only will many endemic plant species become extinct at the ASI, but community composition would also be severely altered. We assessed the feral goats' population status and its habitat use patterns on the island. With this information it was determined whether suggested to hunting by local people would control the goat population. We analyzed a 5-year hunting dataset of, direct observations from on-foot transects, and indirect presence indicators to estimate goat density in each habitat type. We estimated the feral goat population in 2,400 individuals with an annual increase rate of 12%. Feral goats in the ASI used some habitats non-randomly in function of the plant species present, showing active habitat selection. From the 5-year hunting seasons, a total of 2,749 goats were hunted, resulting insufficient for goat population control on the island. We estimated that 764 goats have to be hunted each year to prevent goat population growth.

T11-P02 - Birds in restored riparian forests: effects of patch and landscape characteristics

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It is important to evaluate how restored riparian forests' characteristics influence their attractiveness to birds. Birds may bring seeds to the restored fragments, increasing biotic diversity, thus, to study how birds respond to riparian forest restoration is important to understand the mechanisms of forest restoration. This study aimed to verify if some biotic and abiotic characteristics of the restored riparian forest fragments and of the landscape influence the communities of birds that use restored riparian forests. Transects, point counts and captures with mist nets were used in bird samplings. Results showed that bird richness was positively correlated with fragment size, plant richness and plant abundance inside the restored patches and with the percentage of forest cover in the landscape matrix. The level of urbanization and the percentage of open areas in the landscape matrix were negatively correlated with bird richness. Birds' trophic guilds were also influenced by characteristics of the riparian forest fragments and landscape, especially the percentage of forest cover in the matrix. Riparian forest restoration programs should consider characteristics such as the size of patches, diversity and abundance of plants, and characteristics of the landscape matrix, such as the percentage of forest cover and urban cover. These characteristics increase the chance of colonization by birds, which help in the vegetation succession and enable the forest to become sustainable over the years.

T11-P03 - Effects of translocation on oysters *Crassostrea virginica* to stressful ecological conditions

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Populations of oysters *Crassostrea virginica* growing in the most important Mexican lagoon in the Gulf of Mexico are commercially exploited additionally to being threatened by pollution and climate change impacts. Environmental stressful conditions booster the hazards by promoting the occurrence of infectious diseases caused by parasites that widely distributed in the Gulf

of Mexico oysters populations. Specifically in the present work was aimed to determine the abilities of oysters to respond and adapt to deteriorated ecological conditions caused by human activities. Oysters specimens from less impacted areas were translocated to a worst conditions estuary and metal acquisition, condition index and gill oedema were evaluated, as well as occurrence of *Perkinus marinus* parasites assessed. Oysters subjected to translocation showed a clear successional increase during time (0, 7, 17 and 47 days) on concentrations of zinc body burden. Pathological alterations and high intensities of *P. marinus* occurrence were detected. Translocation of oysters showed the susceptibility of organisms to stressful conditions by promoting outbreaks of infections but groups of oysters showed a great resistance to the new conditions indicated by the absence of the parasites. These findings support the reports and recommendations given by groups of oyster reef restoration in the United States related with the selection of resistant specimens for restoration actions. The management of this resource has been delegated to the local oyster's fishermen without any biological bases for the administration, it is therefore important to promote a better management through the selection of organisms for the recovery of the resource.

T11-P04 - Forest rehabilitation and its effect on plant and bird diversity in Central Mexico

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In 1998, local communities from “El Porvenir, Hidalgo”, Mexico started a reforestation to rehabilitate degraded areas, planting mainly *Pinus greggii*. Nowadays, there is little information in the area about changes on community structures, ecological process and species diversity on both plants and fauna. Our objective was to evaluate the effect of forest rehabilitation on understory and avian diversity in three different reforestation ages of *Pinus greggii* (R5, R12 and R14 years-old), and having a reference site (RS) as well. From January-June 2015, the tree layer and the understory structures, and bird species composition was measured. Only one tree species was recorded in the reforestations, and two species in RS. For the understory composition, 45 species were registered. The index of diversity (H') between conditions, significant differences were found, where the RS presents the greatest diversity of plant species in the understory. The “Poisson regression analysis” (ARP) showed that in the reforestations, 12 variables are related to the abundance of understory species; for RS the most significant variable was the canopy cover. 39 bird species were recorded and there were no significant differences (H') between reforestation ages. According to the ARP, the slope is the variable that explains best the abundance of birds in the reforestations; and for the RS to be the most significant variable for bird abundance was the canopy openness. After 14 years the R14 and RS are more similar, the rest of the reforestation still disturbed but having an important role on flexible avian of modified environments

T11-P05 - Comparative analysis of the impacts of the introduction of common marmoset (*Callithrix jacchus*) on the community of birds in tropical forest ecosystems

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Birds are seed dispersers, contributing to colonization and maintenance of natural ecosystems and to the restoration success, especially in fragmented landscapes. The presence of the marmoset *Callithrix jacchus* in the municipality of Bauru - SP has been registered for more than two decades. Native from the Brazilian northeast and used like pet, the possible causes of introduction of this animal in natural ecosystems have been the release and escape of captivity. We assessed the impact offered by the marmoset on bird species. The study was held in two steps, the first in 2008 and the second in 2013 at The Bauru Municipal Botanical Garden, with the objective of quantifying the predation rate of birds' eggs by marmosets and verifying whether there is change after five years. Eggs with non-toxic modeling mass were placed in artificial nests and randomly distributed on two trails. The analyzes were performed through the dental arch left in the molds. In 2008 the marmosets were responsible for predation of 250 from 364 eggs (68.6%) and in 2013, 90 from 170 eggs were predated (52.9%). Even the rate of predation decreased in five years, it was still high in the end of the study period. The marmosets are mainly responsible for the predation of the eggs, interfering on the bird community. This interference has consequences on the entire ecosystem, considering the role that birds play in seed dispersal and that the study area is considered as a source of propagules for restoration of adjacent areas. .

T11-P06 - Honeydew: Benefit or Threat to Andean Oak Forests Restoration in Santander, Colombia?

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Honeydew is a sugary solution that drips from the anal projection of *Stigmacoccus asper* (Hemiptera: Stigmacoccidae) in interaction with Andean oak (*Quercus humboldtii*) forests and a sooty mold, which grows on trees bark. *Quercus humboldtii* is a 'vulnerable' species, whose use is forbidden in the country, whilst honeydew is harvested by hummingbirds (Trochilidae), *Melipona* bees, and *Apis mellifera* (Hymenoptera: Apidae). These last two take it and produce international quality honey, which represents a potential Non-Timber Forest Product (NTFP) for neighboring communities. Oak trees harboring *S. asper* and sooty mold are abundant at highly intervened marginal fragments. There the insect-plant relationship could be configured as a parasitism, affect oak forests, and require a specific management plan. We report the degree of infestation for oaks at the Natural Reserve of the Civil Society "El Páramo-La Floresta", Zapatoca municipality (Santander, Colombia), where we set up in 2015 four permanent 400 m² plots at 2500 masl. Two years later we measured again DBH, height and tree mortality. We used R and a Kruskal test to find out if the amino acids extracted by insects could reduce trees DBH growth. We estimated a 80% infestation of *Q. humboldtii* individuals, and we found out significant differences with a neighboring oak forest, although mean growth was higher in the affected one. This is probably the first monitoring of oak populations harboring Hemipteran bugs, and preliminary results should be compared with other forests to reach a bottom-line conclusions. If the amino acid extraction do truly impact these threatened oak forests, restoration efforts should be undertaken. Here we suggests guidelines for assessing the sustainability of honeydew as a NTFP as well as a food source for hummingbirds.

T11-P07 - Responses of ant communities to land-use systems and restoration in Brazilian Cerrado

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Among all savannas in the world, the Cerrado (Brazilian savanna) is the most biodiverse and has been the most threatened by land conversion. We use ant functional and taxonomic diversity to examine the effects of different land uses (agriculture, pastoralism, silviculture and conservation) and restoration practices (passive and active by planting trees) on Cerrado biodiversity. We also examine the extent to which ant diversity and composition can be explained by vegetation attributes. We sampled plants and ants in five replicate plots of each of 13 land-use and restoration treatments, including two types of native vegetation as reference sites. Beta diversity was consistently higher in reference habitats and restored treatments compared with production land uses. Ant species and functional composition varied systematically among land-use treatments following a gradient from open habitats such as agricultural fields to forested sites. Tree basal area and grass cover were the strongest predictors of ant species richness, reinforcing the notion that highest biodiversity loss occurs when land-use systems involve transformation of vegetation structure. Uncleared pastures are therefore the most friendly land use for preserving Cerrado ant species in production systems. Restoration techniques currently applied to Cerrado have been successful in returning tree cover, but fail to restore ant communities typical of savanna. For improved Cerrado restoration, greater attention needs to be paid to the grass layer, including recognition that fire is crucial to the maintenance of Cerrado biodiversity.

T11-P08 - *Rhinella schneideri* (Anura, Bufonidae) as bioindicators in a riparian forest recovery

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Fauna analysis and its use of resources in restored areas can be important indicators of success in restoration projects. The effectiveness of the reforestation of riparian forests in promoting the return of the fauna after 10 and 20 years of planting around a reservoir of hydroelectric power plant was evaluated from the analysis of diet and trophic stress of the anuran *Rhinella schneideri*. The study was conducted in the Cerrado area of Minas Gerais, Brazil. Anurans were collected by pitfall traps in five recovered riparian forest patches with 30m and 100m wide over a year. Stomach contents and body symmetry of adult of *R. schneideri* were analyzed. Body asymmetry has been used as a measure of the level of stress to which individuals are subjected. Colonizing anuran species were characterized as resistant to anthropogenic alteration, habitat-generalists and presented a wide distribution through Brazilian biomes. As a pioneer and r-strategist species, *R. schneideri* was the most abundant anuran species in all studied patches; its density was high in the smaller and younger patch. In older restored patches, there was a decrease and stabilization of the population density. The prey consumption by *R. schneideri* was lower in the larger and older patch, where ant availability and anuran diversity were higher. These two factors led to high stress, expressed by the greater body asymmetry. The progression of the successional process and the recovery of the environment favored the increase in species richness, which exerted control in the population density of colonizing species. It is concluded that the variation in the asymmetry, diet and density of pioneer species can be used as bioindicators of the recovery of reforested areas.

T11-P09 - Forest restoration initiative driven by the need to reduce the damage caused by a primate species to exotic pine plantations in Brazil

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Primates are important seed dispersers and the species that can occupy modified habitats contribute significantly to ecological restoration. Black-horned Capuchins, *Sapajus nigritus*, fall into this group, dispersing over 50 plant species in South Brazilian Araucaria Forest alone. Nevertheless, they are accused of being forestry pests, since during seasonal periods of fruit scarcity they feed on exotic pine (*Pinus* spp.) sap, hindering tree growth and survival. In order to reconcile production and conservation we have proposed the enrichment of native forests situated nearby pine stands with zoochoric species as a tool to reduce damages. The selection of plant species was based on the frugivorous diet of *S. nigritus*, favoring those that produce fruit during periods of food shortage. The list includes 25 native species with variable ecological traits. In October/2016 we have started the enrichment (1,000 seedlings/ha) of impoverished Araucaria Forest remnants found within three properties in Southern Brazil and our expectation is to plant 132,000 seedlings. In the meantime, we are monitoring seedling survival/growth, pine bark-stripping by capuchins, and habitat use by vertebrates both within restored and control areas. We expect the increase in fruit availability not only to reduce capuchins' demand for pine sap but also to improve local and regional biodiversity indicators. So, even though restoration actions can be species-oriented or driven by specific situations, the outreach is still expected to be wider. Besides, the reconciliation of interests constitute a great opportunity to effectively restore large expanses of private land.

T11-P10 - Composition and distribution pattern of Littorinid snails in young rehabilitated mangroves, Xiamen Island, China.

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Littorinid snails are common benthos in mangrove forests, variously dependent on the mangrove habitat for its morphology, feeding and behavior characteristics. In this paper, the composition and distribution patterns of Littorinid snails in young rehabilitated mangroves (Xiamen Island, Fujian province, China) were investigated, and the influences of the tidal flat elevation and vegetation types were studied. The results showed that Littorinid snails occurred in the mangrove forests at early rehabilitation

stage, with a high density up to 32.67 ind m⁻². *Littoraria melanostoma* was the dominant species in *Kandelia obovata* forests, and its density as well as biomass was found to be higher in the *K. obovata* forest with an elevation of 1.8 m than that planted at 2.2m or 2.6 m tidal elevation. *L. scabra* was also common in this study, but was only collected at the forest with 1.8 m tidal elevation. The Littorinid community was also compared between a *K. obovata* forest and an *Aegiceras corniculatum* forest planted at the same tidal elevation of 1.6 m. The density and biomass of *L. melanostoma* were significantly greater but the body size was smaller in *A. corniculatum* forest than in *K. obovata* forest. There was no significant difference in the neither the abundance or the body size of *L. Scabra* between the two mangrove species. These differences in Littorinid snails composition and distribution pattern may be related to variable physical-environmental conditions resulted from the plantation of mangrove with different morphology, and biological characteristics of the snails, such as the activity habit and the propagation pattern.

T11-P11 - Early successional wildlife monitoring of reclaimed habitats in the Alberta Oil Sands Region of Canada: Indicators of ecosystem shift

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Anthropogenic disturbances are occurring in the Athabasca Oil Sands Region of northeastern Alberta, principally from surface mining, in-situ, and conventional oil and gas development. These disturbances include habitat loss through deforestation and habitat alteration and the installation of mining infrastructure such as roads, tailings ponds, and upgraders. Concurrent with disturbance and active mining is the reclamation of upland habitats. The success of this reclamation is contingent (in part) upon the quantification of the return to and use of reclaimed habitats by wildlife. To that end, an effectiveness monitoring program has been implemented in the region to assess the return and re-establishment of wildlife to reclaimed upland habitats relative to the seral stages through which the reclaimed habitats will develop, to natural analogues of similar age, and to mature forest reference points. These data will also contribute to the state of knowledge regarding the efficacy of approaches to upland habitat reclamation as it pertains to the creation of functional wildlife habitat. Appropriate indicators of ecosystem shift are necessary to track the developmental trajectories of reclaimed habitats over time and indicators species need to be considered in context to their life-history requirements, behaviours, and site-characteristics of the habitats being studied. The analysis of data collected between 2011 and 2016 suggest that certain species of songbirds (sparrows) and terrestrial arthropods (spiders and beetles) are indicative of the habitats through which reclaimed habitats will develop, providing the data necessary to track ecosystem shifts and assess reclamation effectiveness. Continuing investigations into these species-habitat associations are occurring to determine the strength and persistence of these relationships over time.

T11-P12 - Fruit dispersal dynamics and its implications for restoration of the cold desert shrub *Zygophyllum xanthoxylon*

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The pattern of seed dispersal in time and space can affect plant fitness and the soil seed bank, and thus information is needed on this aspect of the seed biology of a species before it is selected for use in habitat restoration projects. *Zygophyllum xanthoxylon* is a super-xerophilous shrub that is a potential pioneer species for use in revegetating highly disturbed areas of the cold deserts of northwest China. We studied fruit release and soil seed banks of *Z. xanthoxylon* for three years in its cold desert habitat. Fruit (a three-winged capsule) release began in summer (June 2010, August 2011, July 2012) and extended for 9-10 months. About half the fruits were released in the first two months after maturity, while the others were released gradually over a 7-8 month period. The temporal pattern of fruit dispersal varied with habitat but not with amount of precipitation during summer. Some seeds dispersed in June-August germinated in response to summer rain, while those dispersed in autumn and thereafter become part of the soil seed bank. The pattern of fruit deposition on the soil surface was affected by neighboring plants, wind velocity, wind direction and topography. In both habitats, >90% of the fruits was deposited beside large and small clusters of plants, mainly *Ephedra przewalskii*. To facilitate plant community development, we suggest that *E. przewalskii* should be planted (as a wind break) together with *Z. xanthoxylon* when native pioneer species are used for restoration of cold desert shrublands.

T11-P13 - The characteristics of soil fauna's community structure in the degraded red soil region

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The red soil region in south China which occupies one fifth of the total soil area in China, became to be one of the most serious areas of water and soil erosion in China due to the natural and artificial factors. Nowadays, the forest revegetation and rehabilitation of degraded red soil arouse wide concern in the ecology. The study chose a serious degraded red soil region in Taihe, Ji'an of Jiangxi province as the research area, besides, 4 managed sample plots (Conifer Forest, conifer-broadleaf forest, deciduous broad-leaved forest, Evergreen broad-leaved forest) and 1 unmanaged sample plot (grassland) were chosen. In each of plots, 5 treatments were set according to "S". the soil sample were got by using soil-drilling method and the soil fauna were collected by Tullgren method and pitfall trap, then the soil fauna were classified and counted. The results showed that: A total of 3721 soil animals were captured, belonging to 21 orders, 8 classes and 4 phyla. Araneae, Coleoptera and Collembola were the dominant groups, while Lycosidae, Atypidae, Myrmicinae, Ponerinae and Entomobryidae were the common groups. The Margalef species richness and the DIC index of the soil fauna in grassland were 4.609 and 10.537, respectively, and it suggested a highest species richness and diversity. Compared with other 3 managed sample plots, the DIC index of conifer forest was the highest (7.515). Meanwhile, the highest Simpson index number was observed in deciduous broad-leaved forest, reaching to 0.872, which showed that it had a great species richness and dominance.

Fauna: restoring wildlife

T12-P01 - A case study on the effectiveness of forest corridors: Afetiva Ranch (Silva Jardim, RJ, Brazil), planted to aid in conservation of Golden Lion Tamarins (*Leontopithecus rosalia*)

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Habitat loss and fragmentation in Brazil's Atlantic Forest are two threats to endangered Golden Lion Tamarins (GLTs), for both demographic and genetic reasons. Conservation is further complicated by the fact that the species' range is restricted to forests below 500m elevation, most of which is in only two municipalities of Rio de Janeiro state. Thus, planted forest corridors are important tools to reestablish landscape connectivity and contribute to GLT conservation. As an example, we document the creation and conservation impact of the Afetiva Ranch forest corridor, Silva Jardim municipality, planted by the Forest Restoration Program of Golden Lion Tamarin Association. The Afetiva corridor was planted in two stages: 6.05ha in 2010, and 5.2ha in 2015, yielding a total of 11.25ha—all located along streams. This corridor was planted to connect GLT populations in two forest fragments: Imbaú I with 268 GLTs on 3,043ha, and Imbaú II with 28 GLTs on 58ha. Restoration techniques included planting native tree seedlings and forest enrichment. The corridor was fenced to exclude cattle. Initially there were two GLT groups in the Imbaú II fragment, with 13 and 4 GLTs. Beginning in 2016, two new groups formed, with 4 and 5 individuals. One of the latter groups made use of the planted corridor. In 2016, 4 GLTs used the planted forest corridor to migrate from Imbaú I to the Imbaú II. We conclude that the forest corridor achieved its objective of reconnecting 3,101ha of lowland Atlantic Forest, and their GLT populations.

T12-P02 - Diversity of the bat community (Mammalia: Chiroptera) in reforestation areas of *Eucalyptus* spp. and in remnants of natural vegetation of the Rio Claro farm, Lençóis Paulista, SP

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Currently in Brazil millions of hectares are destined for plantations of the genus *Eucalyptus*, these plantations might cause the local loss of biological diversity. The Order Chiroptera is important in the recovery and maintenance of forest areas, being the main mammals are seed dispersers in the tropics and responsible for pollination of hundreds species. Considering the protection of species, and aiming to interconnect production with conservation, we made an inventory of bat fauna in an area reforested with *Eucalyptus* spp. and in an area of native forest, these being contiguous. The study was conducted at Rio Claro farm, Duratex S.A's property, in the city of Lençóis Paulista, São Paulo state. The research of the capture and data collection was done between October 2007 and July 2010, totaling 42 nights, four sample areas were selected, two of which had reforestation of *Eucalyptus* spp. and two with native forest. In each sampling area 10 mist net were used (12 x 2, 5 meters), amounting 40 nets that were exposed 12 hours per night. 217 individuals from 20 species and 3 families were captured, the Phyllostomidae family being the most abundant (n = 190) and diverse (13 species). From the phyllostomids listed 10 species are considered phytophagous, eight are frugivorous and two are nectarivores, these species are responsible for the dispersion of seeds and pollination of hundreds of plant species, providing a valuable ecological service to the environment. The results reinforce the importance of bats in maintaining the natural regeneration process of the areas.

T12-P03 - A management strategy for protecting wildlife nesting sites from Africanized honey bees

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In 1994, a program using barn owls (*Tyto alba*) as a sustainable means of rodent control was established in the Everglades Agricultural Area of south Florida. Based on the placement of man-made nesting boxes on field perimeters, the project met with great success, with over 90% of nesting boxes ultimately housing nesting or roosting. However, beginning in 2005, it was noticed that honey bees were colonizing some of the nesting boxes, using them as hives. Eventually, two out of every three boxes were taken over by bees. These turned out to be invasive Africanized honey bees (AHB) which swarm much more frequently than European honey bees, and which are also less rigorous in selection of potential hive sites. Research has demonstrated that a push-pull IPM strategy using an encapsulated permethrin insecticide inside the nesting box, along with a pheromone-baited swarm trap in the vicinity of the nesting box, has proven very effective in alleviating this threat. The insecticide, with extremely low mammalian and avian toxicity, has no negative effects on the birds, and may even have benefits, as in reducing parasitism by hemophagous insects such as mosquitoes and lice. Additionally, wild AHB swarms attracted to swarm traps may be easily removed for safety reasons and perhaps even converted to commercial quality hives by re-queening with European honey bee queens. This strategy has also proven beneficial in other situations, such as that faced by macaws and other cavity nesters in the Brazilian rainforests.

T12-P04 - Ongoing monitoring of the reintroduced stitchbird (*Notiomystis cincta*) population under changing supplementary feeding on Kapiti Island

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Supplementary feeding (SF) is a commonly-used management tool for species conservation and has been often used for reintroduction of birds in New Zealand. However, due to limited resources for restoration programs, its benefits must be evaluated – as part of ongoing monitoring for adaptive management. This work is a case study of the demographic effects of SF regimes on hihi (*Notiomystis cincta*) in Kapiti Island. Capture-Mark-Recapture data was analyzed for the period from 2001 to 2016, under three different SF regimes (ad libitum, limited I, limited II) – with the unlimited food was capped in 2009 and increased in proportions in 2013. We have used Cormack-Jolly-Seber models in RMark to estimate the survival of the population. They included time, sex and food category as factors, and were averaged by using the Akaike Information Criterion (AIC). The population growth was also estimated for each respective year, through POPAN formulations. Our results show that during “limited I” SF regime, the population abundance and the survival probabilities for males and females had declined. It was then stabilised during “limited II”. We suggest that the efforts to increase SF during the last regime had stopped the decline and that there may be other factors explaining why the population has not recovered to “ad libitum” levels yet.

T12-P05 - Rehabilitation and management for sand martins (*Riparia riparia*) at mining areas

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The sand martin (*Riparia riparia*) is a bird with conservation value in Europe and is one of the species which interacts most with gravel pits. Its populations in Europe are primarily located in mining areas, so their colonies are subjected to constant and rapid changes caused by mining activity. This can compromise the success of settled colonies in mining areas and therefore, sand martins depend critically on the management of these spaces. The object of this project was to promote the reconciliation between mining and conservation of the sand martin. To achieve this we studied how to influence the location of sand martin colonies in gravel pits, so as not to interfere with mining activity. Two experimental sand structures were created at a gravel pit in Spain. They were simple, easy to build, low budget structures, made from material present in the gravel pit. The structures were a success, as both of them were colonized by sand martins (56 pairs) and reproduction was observed. Secondly, a guide for

the management of sand martins in gravel pits was developed. The aim of this guide is to help gravel pit managers in a clear way towards management actions for the sand martin. Future studies carried out in 2017 aim to compare the reproductive activity of sand martins in mining areas with ones located in more natural environments. This will help propose management measures of this species both in the exploitation phase of the mine and in the final phase of restoration.

T12-P06 - Perches as a strategy to restoring biodiversity in urban parks

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Nucleation techniques consist in a modality of restoration that aim to use the succession processes to restore areas and they have been usually studied in rural ones. This project motivation is based on the lack of nucleation techniques studies in urban areas, which is normally poor in terms of biodiversity. The research was carried out in three urban parks, Chico Mendes Park (Ch); Biodiversity Corridors Municipal Park (Bio), and Botanical Garden (Bot) located in Sorocaba – SP, Brazil. Twelve perches (1.5 m tall) were installed in each study area, with some experimental variations. The monitoring consisted in analyzing the presence of vestiges, traces and plants germination. It was used the municipal birds database to evaluate the community composition and analyze the performance of the perches. Despite perches being visited by birds, there was poor plants germination and, in some places, the human presence damaged to perches due to some depredation. There are in the study areas 117 birds species (100Ch; 86Bio; 8Bot) of which only 36 show dispersion potential with their feeding bases. Even though there are 23 frugivore or granivore species, the feeding troughs were not visited in Bio what may have been caused by the foraging stratum of the species in it. Only 16 species are of terrestrial or understory, suggesting that taller perches would be better for this place what would be impossible in urban areas. This study is a pioneer on these techniques in urban areas. Hence, further researches are important to assess their effectiveness.

Governance and public policies/legislation

T01-P01 - The effect of Resolution SMA 07/2017 on the calculation of forestry compensations legally assumed by road projects in São Paulo State, Brazil

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The environmental licensing of road projects and the issuance of Vegetation Suppression Authorization - ASV are conducted in São Paulo State - SP, Brazil, by São Paulo State Environmental Agency - CETESB. ASVs are issued after entrepreneur signs an Environmental Recovery Commitment Term (TCRA), in which he agrees to implement an ecological restoration project whose extension is calculated in accordance with current legislation. A new state legislation was issued (Resolution SMA 07/2017), which establishes criteria and parameters for forestry compensation of areas subject to ASV in Atlantic Forest Biome. In order to understand the effect of this Resolution on the calculation of forestry compensation, a comparison was made with all TCRAs signed in SP for road projects in 2016. This year 45 TCRAs were signed, with an area of compensation of 310.80 ha. If the calculation had been made by the new Resolution, these TCRAs would add 344.76 ha, an increase of 11%. In spite of the suppression vegetation fragments, the new resolution leads to increases of 25 to 600% in compensation, but for isolated trees there was a reduction of up to 60%. The small increment in the TCRAs for road projects is due to the high number of isolated trees. The new Resolution is innovative to environmental conservation as it establishes a priority scale for municipalities considering their importance in water resources and native vegetation preservation.

T01-P02 - The Environmental Rural Registry (CAR) as tool to benefit forest landscape in Brazil: a study in the Atlantic Forest.

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The Federal Law no. 12,651/2012 has established the so called new Brazilian Forest Code, which created the Environmental Rural Registry (CAR, in Portuguese), a mandatory digital registration that gathers information on the situation of Legal Reserve Areas (20% of rural properties in the Atlantic Forest). Considering CAR may assist environmental planning in fragmented landscapes, this study aimed to verify whether the proposed location of Legal Reserve Areas in rural properties may bring benefits to forest restoration in the Environmental Protection Area of the São Joao River Watershed, Rio de Janeiro State. Data on the proposed location for Legal Reserve were collected from the CAR cartographic database from May 5, 2014 to May 5, 2016, for 406 rural properties, mostly family farms. According to the CAR, those properties cover 44,892 ha, and 15,747.49 correspond to native forest remnants. Despite the proposed Legal Reserve Areas account for 9,739.15 ha, shapes are not even close to each other, or to local protected areas, or even to local forest remnants, suggesting a low contribution to local landscape forest restoration. CAR registering also mapped overlaps among properties boundaries and declared Legal Reserve Areas. CAR was proved an important tool to enhance forest restoration and the reestablishment of ecosystem services by planning the location of required Legal Reserve, forming future ecological corridors. However, our results suggest that agrarian registers need to be updated, and policies are required to stimulate rural landowners to plan land use in order to benefit forest landscape and bring environmental services back.

T01-P03 - Conservation strategies in the Bogotá botanical garden Jose Celestino Mutis

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The Bogotá botanical garden mission is to contribute to: the flora conservation in Bogotá and its influence area, the environmental sustainability in the territory and the genetic patrimony use through the scientific research, technological exchange and the environmental education. A over 150 people team, comprised of professionals, technicians and trained gardeners is conducting research projects, within the framework of 12 interrelated investigation lines, congruent with the conservation objectives of the garden. Those investigation lines embrace: 1. Ecological characterization and ecosystem services assessment of priority areas. 2. Design and execution of ecological restoration models. 3. Adaptive management of areas with ecological restoration research projects. 4. Development of research in biotic and abiotic interactions on the vegetation coverage in Bogotá and its green areas. 5. Promotion of the progress in the high Andean ecosystems research. 6. Dissemination of the knowledge concerning to the conservation and sustainable use of the biodiversity in academic environments. 7. Bogota Flora research as a strategy for the adaptation against the climate change. 8. Enrichment of the live collection of the Bogotá Botanical Garden. 9. Increase the reference collections in the Bogotá Botanical Garden. 10. Integral characterization of strategic species for the adaptation to climate change. 11. Conservation, restoration and use of those species for its introduction in the urban vegetation coverage. 12. Determine the propagation protocols for the strategic species in conservation. Finally, the generated knowledge is articulated by processes of social appropriation and application to preserve these resources and to enhance the citizen's life quality.

T01-P04 - Forest Restoration and Environmental Regularization in Agrarian Reform Settlements in Brazil: how to make this possible?

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Brazil has 88.8 million hectares of settlements for the agrarian reform. In order to comply with the Forestry Law, the government, in partnership with settled farmers, will have to restore areas that have been irregularly deforested in these settlements. However, besides not having an estimate of the size of the total area to be restored, many problems challenge the accomplishment of this task, such as the obstacles of public bureaucracy and the inefficiency of technical assistance. In order to quantify the amount of areas of natural vegetation that need to be restored and to analyze the best strategies to enable their restoration, we studied the settlements located in the sub-basin of the Alto Xingu, in the state of Mato Grosso. The results showed that the changes in the Forestry Law in 2012 practically exempted the need for restoration of 81,457 hectares of legal reserve that existed in the 37 settlements of the region. Nevertheless, there are still around 3,270 hectares within permanent preservation areas that need to be recovered. This study identified local initiatives that have been able to organize the necessary conditions for the processes of forest restoration in the region. The proposed solution for promoting the regularization of the settlements is the integration of the government to these initiatives, by qualifying the local socio-technical networks and the associations of settlers as social organizations and by establishing contracts of management. These conditions may promote the generation of employment and income to the settled families.

T01-P05 - Native ecological restoration techniques employed in Brazil

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Recently, the Brazilian government committed to restore and reforest 12 million hectares of forests until 2030 (Nationally Determined Contribution - NDC). Seeking to strategically subsidize large-scale restoration policies for Brazil, IPEA and TNC, with the support of EMBRAPA, the Brazilian Ministry of the Environment - MMA and the Deutsche Gesellschaft für Internationale Zusammenarbeit - GIZ, developed a study to characterize the main ecological restoration techniques applied in distinct biomes of Brazil. The methodology consisted in identifying widely used materials and management activities. To accomplish that, consultations were made with project executives, academic experts and public managers from various regions of Brazil. We received

94 responses that contributed to the analyzes performed. The result of this evaluation allowed the description of techniques, for each Brazilian biome, in terms of the following information: main inputs and activities employed; usual amount of inputs and labor (man-hours) employed; steps in which each input and activity is used (implementation phase and/or maintenance phase) and a general outline of each technique. Our results show large variability in the characteristics of intensive techniques, well established in the technical and scientific literature (e.g., dense tree planting of several species through seedling), as well as in techniques based on natural regeneration. The expressive number of projects reporting use of the latter (both with and without management) highlights the search for efficient results in ecological terms at lower cost and with easier implementation, focusing on natural processes and mechanisms of ecosystems recovery.

T01-P06 - Laws and forest cover changes in a rural/urban watershed in Brazil

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Forest restoration in Brazil is regulated by many laws, which have been changed in the last few decades. In this study, we aimed to evaluate changes in the forest cover in a 873 ha watershed, through passive and active restoration (from 2006 to 2014), in compliance with these laws. This study area can be considered as inserted in a rural/urban context. For this, we have used free geotechnologies (QGIS and Google Earth). From 2006 to 2014, there was an increase of 85,74 ha in forest cover, most of it as result of passive restoration. We also made a simulation of legal compliance, considering three different scenarios. Considering an ancient law (from 1965), there would be 46,55 ha to be restored. However, according to a new forest law (from 2012), the requirement would be of 8,31 ha (if all the rural properties in the watershed were considered small), or of 40,86 ha (if the properties were of larger sizes). This law has different requirements for rural properties of different sizes. These results show that legal compliance have been positive in encouraging forest restoration in rural and urban landscapes. However, recent changes in the forest laws can cause a drastic reduction in forest cover in most landscapes. As already shown by many studies, this can lead to a decrease in the quality of these landscapes, with less conservation in natural and agro ecosystems, and reductions in the capacity of these ecosystems to provide environmental services.

T01-P07 - Public policies and ecological restoration in Brazil: process of elaboration of the Environmental Compliance Programs in the states of Acre, Rondônia and Bahia

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In 2012, the promulgation of changes in the Forest Law brought challenges to the elaboration and implementation of its new instruments, mainly the Environmental Rural Registration and the Environmental Compliance Programs (CAR and PRA, acronyms in Portuguese). The elaboration of the PRA is in charge of state governments, in Acre, Rondônia and Bahia, the development of PRA was supported by ESALQ / USP researchers based on three main themes: (1) approaches for restoration implementation and ecological parameters for its monitoring; (2) administrative mechanisms to support program management by state agencies; and (3) the construction of a legal instrument to regulate the program. This process was led by each state government, together with NGOs and private companies. An important aspect of this process in these three states is that it was an open process, on which different decision-makers and stakeholders involved in the 'restoration supply chain' at each state had to be part of the PRA elaboration process to foster the creation of an implementable policy. This involvement is crucial to the efficacy of the policy, since the PRA is self-declaratory and demands a long term monitoring and adaptive management. In open meetings, these different stakeholders discussed and recommended the most appropriate restoration approach for each biome, environmental characteristics and socioeconomic situation, based on their previous knowledge and scientific data. Were also discussed with the state governments, the ecological parameters that indicates the restored area is following an acceptable trajectory and has a real chance to evolve to a self-sustaining ecosystem.

T01-P08 - Restoration of disturbed forests in human-modified landscapes: Developing a reference document to guide practice

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Traditionally, the “natural forest management” concept refers to reduce the logging impact on tropical forests, and is usually related to economic goals. However, in tropical human-modified landscapes, forest fragments are severely reduced and subject to recurrent impacts, such as logging and fire, which affects forest structure and composition. Therefore, forest restoration should focus on strategies to increase their potential for biodiversity conservation and provision of ecosystem services. So far, ecological restoration has focused on strategies to recover open areas, while disturbed forest fragments has been neglected. For that matter, a group of Brazilian specialists, led by The Nature Conservancy and Fundação José Pedro de Oliveira, gathered to discuss issues related to forest fragment’s restoration, aiming to create a reference document to review the literature, propose strategies to foster this research area and to discuss its limitations. Subjects are divided into six major topics: 1) legal instruments and limitations related to disturbed forests restoration practice in Brazil; 2) landscape ecology and its influence on disturbed forests’ conservation potential; 3) ecology of climbers and their impacts on disturbed forests communities; 4) Fast ecological assessment framework to guide decision-making, showing about control of degradation factors and focused on the restoration of Semideciduous forest fragments and landscape around; 5) review of restoration methods and practical guide applied to disturbed Semideciduous forests; and 6) experiences gathered from the restoration of protected areas. This document might encourage scientific discussion on disturbed forests restoration and offer a reference document to support its practice in human-modified landscapes.

T01-P09 - SMA Resolution 32/14 in restoration projects of road enterprises in São Paulo State, Brazil

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In São Paulo State, Brazil, environmental licensing and issuance of vegetation suppression authorization (ASV) of road enterprises are conducted by Sao Paulo State Environmental Company (CETESB). ASV’s issuance depends on previous signing of an Environmental Recovery Commitment Term (TCRA), in which the entrepreneur agrees to implement an ecological restoration project as forestry compensation. In 2014, SMA Resolution 32/14 established criteria for ecological restoration in the State, increasing possibilities of using different methods (e.g, nucleation, enrichment and total planting) and focusing on final results. The TCRA has been evaluated with approved restoration projects, signed after SMA Resolution 32/14 in road enterprises licensed by CETESB. There were 26 TCRA, adding 402,368 ha of compensation area: 25 (401,378 ha) have proposed total planting (planting of seedlings in the whole area) and just one (0.99 ha), enrichment. Despite the great possibility of different methods this law has brought, the preference for total planting can be explained by its large use, and the entrepreneurs have greater knowledge on costs and execution. The enrichment project was conducted in Cerrado (Brazilian Savanna), a biome known for its unsuccessful total planting in ecological restoration. Furthermore, methods such as natural regeneration conduction are accepted by CETESB just if they are combined with perturbation factors eradication, what is unusually used by entrepreneurs. We concluded that SMA Resolution 32/14 has not effected a change in restoration methods most employed by road enterprises so far, but its focus on ecological indexes instead of number of species and seeding may change this pattern.

Monitoring/Indicators/Adaptive management

T24-P01 - Monitoring restoration success of soil's quality in forested ecosystems: A global meta-analysis

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The ecological restoration process and its success depend to a large extent on the soil's integrity and functionality. Despite recent global meta-analysis regarding restoration success patterns for biodiversity and vegetation structure, yet understanding restoration success of soil's quality in forested ecosystems remains unclear. We conducted a global meta-analysis encompassing 432 quantitative comparisons between restored and reference (e.g. old-growth forests) forest systems to compare restoration success of soil quality indicators (soil organic matter, biological, chemical and physical). As expected, we found that all indicators were more depleted in restored than in reference systems. Biological indicators (-0.55) were more depleted than soil organic matter (-0.38), physical (-0.19), and chemical (-0.02) indicators. Our study shows that restoration practitioners should focus more effort on restoring biological soil fauna since it showed the most contrasting difference between restored and reference systems. This global meta-analysis provides insights not only in the trends of restoration success of soil quality, but also into which indicators are more critical to be restored and monitored in order to achieve more cost-effective restoration of soil's quality.

T24-P02 - Characterization of soil arthropod fauna in mining areas at different stages of revegetation

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Mining has huge importance for economic growth and development in Brazil, although it causes considerable environmental impact that must be repaired. The effective recovery of the ecosystems being restored after mining shall be verified (or monitored) through bioindicators, and soil fauna has been reported as an option. We investigated if soil arthropod fauna can be used as indicator of ecosystem recovery in waste dumps at different stages of revegetation (ages varying from 1 to 4 years) of a mining site located in the municipality of Bela Vista, MG. Arthropod collections were performed in 2016, using 80 pitfalls in four areas of waste dumps. A total of 11004 arthropods belonging to four classes were collected: Arachnidae, Chilopoda, Diplopoda and Insecta. The Insecta class had the highest abundance, corresponding to 94% of the individuals collected. The orders Hymenoptera (75%), Diptera (11%) and Coleoptera (8%) were the most abundant, in decreasing order. Hymenoptera was the more widely distributed in the sampling areas, indicating a broad niche exploration. The Formicidae family presented the greatest abundance in all areas sampled. Ants favor the aeration of the soil, a fundamental role in the ecosystem recovery. Although presenting differences in the vegetation structure due to the time since the beginning of revegetation, the study sites presented similar abundance of invertebrates. Even though the abundance of Arthropods can be assessed as indicator of soil fauna recovery, it does not represent the recovery of the ecosystem as a whole, since it does not correlate with vegetation structure and successional stage.

T24-P03 - Effects of soil chemical and physical attributes on the development of the forest community under restoration

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Forest restoration success is usually measured by the monitoring of vegetation development, with limited knowledge on how soil properties affect this development and on how soil attributes changes with vegetation recovery. This study aimed to identify how the soil attributes affect the development of native vegetation in a tropical forest restoration site and to investigate the changes in soil chemical and physical attributes with vegetation recovery. We expected improvements in soil indicators in the restoration site when comparing to the pasture, however, the restoration planting would still be different in soil properties when comparing to the reference forest. Besides, within the restoration site, we expected to find higher development of the tree community in areas of higher soil fertility. We measured canopy cover and tree seedlings density and richness in 25 x 4 m plots placed in an eight years old restoration planting and in a reference forest, both located at Itu-SP, Southeastern Brazil. In these same plots and in a surrounding pasture, we evaluated soil chemical attributes and compaction (penetration resistance). We found similarities between the restoration site, the reference ecosystem and the pasture for most of the soil chemical attributes. However, soil compaction was higher in the pasture and showed a negative correlation with soil organic matter. We found no relation between the indicators of soil fertility and the development of the vegetation in the restoration planting, suggesting that other factors may affect local variation of native vegetation development in restoration plantings.

T24-P04 - Ecological indicators: From early warning to the preventive and corrective actions

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Dryland ecosystems are experiencing weather events of novel magnitudes that can cause a switch into alternative ecological regimes. In the Caatinga (Northeastern Brazil), drought has become increasingly intense and persistent, with the typical vegetation of semiarid climate being replaced by arid ones, enhancing the desertification process. Providing tools for early detection of desertification signs is, therefore, a new challenge for the scientific community, to avoid irreversible damage to the ecosystems. In this sense, functional diversity (which includes functional traits) is a suitable tool to assess the community responses to climatic and environmental changes. Characterizing plant functional traits along environmental gradients can be an ecological indicator for the early detection of climate change. The aim of our study was to identify functional traits of plants that respond to a climatic gradient in the Caatinga. In search for the relationship between functional traits in the community and climate conditions, we assessed four functional traits: presence/absence of latex; growth form, height and the status of being a legume or not and nineteen variables from global climate data sets. We found no relationship between frequency of legumes and climate. Plant height was correlated with the largest number of climate variables and growth form presented the highest correlation value (Temperature Seasonality: $r = 0,7989$; $p = 2.903e-06$). Although we are only at an early stage of the study, we expect our results can guide restoration projects at the regional level and also that this methodology can be applied to other semiarid areas around the world.

T24-P05 - Reference values used for evaluating the success of restoration in Atlantic Forest

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Determining the success of the restoration project is one of the most important steps of the restoration project and a challenge for restorationists. Several ecological indicators (EIs) have been proposed for monitoring the tropical forest restoration (for example, tree or seedling species richness, basal area, density) and, associated to each ecological indicator, reference values (RVs) are established based on reference ecosystems, which are frequently used to drive legal frameworks. Faced with the need

to know these RVs, this study aimed to estimate the expected structural parameters (species richness and basal area) for areas under natural regeneration in different typologies of Atlantic Forest (Dense, Mixed and Seasonal Forests). We compiled data (forest structural parameters) from literature and built logarithmic and linear models to predict the RVs in different forest ages. We found the basal area was the least variable parameter across the different forest types suggesting that this is good EI to be used towards the restoration effectiveness. In general, the estimated basal area for restoration areas with ~20 years is $22.36 \pm 7.47 \text{ m}^2\cdot\text{ha}^{-1}$, for ~50 years, $28.97 \pm 6.04 \text{ m}^2\cdot\text{ha}^{-1}$, and for ~70 years is $38.58 \pm 7.95 \text{ m}^2\cdot\text{ha}^{-1}$. Differences were observed among forest typologies. We will discuss the implications of using different EIs and the importance of considering differences in forest typologies for establishing legal rules.

T24-P06 - On the assessment of native species in degraded areas of rupestrian grasslands

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The rupestrian grasslands stand out for their high biodiversity and the exceptional proportion of endemic species, but they have been threatened by various human activities (e.g., mining), which make natural regeneration difficult and almost non-existent. The introduction of native plant species is an effective technique to restore ecosystems that present low resilience, such as the rupestrian grasslands. Long term monitoring should be preferred to identify the best restoration actions. For this study, we have introduced eight native species in degraded areas at Serra do Cipó, MG, Brazil, whose vegetation was completely destroyed and the soil was profoundly altered due to land use (heavy equipment parking area). We assessed the survival and growth performance of eight native species transplanted in a rupestrian grassland degraded area over a period of 8.5 years. All analyzed parameters varied over time for most of the studied species, reinforcing the importance of long term monitoring in restoration projects. Also, growth performance indicated aboveground biomass losses and great resprouting ability, which might allow species to overcome unfavorable environmental conditions (e.g., long dry periods and potential fire events). As result, this increases the persistence of species in the area. In this kind of constrained environment, survival and resistance should be favored rather than fast growth and ground cover. In general, the studied species showed to be potential candidates for restoration projects in rupestrian grasslands.

T24-P07 - Collembola as a bioindicator in Brazilian subtropical rainforest restoration

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Using functional aspects of Collembola can be recommended as an advanced method in monitoring environmental changes. We evaluated the role of Collembola as a bioindicator in different forest restoration technologies at the experimental farm of the Universidade Tecnológica Federal do Paraná, Dois Vizinhos-PR, southwestern Parana, Brazil. The study area was previously used by pasture and annual crops before the clear cutting for experimentation. The treatments assessed were: Passive Restoration (RP); Nucleation (NC - set of techniques applied just in 1/3 of the area: artificial perches and shelters for animals; seed bank and rain seedlings planted in islets; cover crop, bromeliads and 36 trees spp. islets); High Diversity Plantation (HDP - plantation using 10 “filling” and 60 “diversity” tree species planted in lines) and Reference Area (RA). The experimental design was in randomized blocks with four replications and six samples per plot. Collembolan individual were collected by the Berlese-Tüllgren method 5 years after restoration implantation. We classified them in Morphotypes Ecomorphological Index (EMI): 2,429 collembolan were identified in 35 morphotypes (10 edaphic, 15 hemiedhatic and 10 epigeic). The richness of morphotypes and the diversity (H') were higher in RA. Abundance was higher in HDP and RA. PCA ($PC1=31.4\%$; $PC2=21.3\%$) and Analysis of Similarities ($R=0.38$, $p = 0.04$) showed differences in the composition of Collembola morphotypes between restoration technologies and RA, emphasizing its sensitiveness to changes in the ecosystem and potential as a bioindicator for monitoring subtropical forest restoration projects in Brazil.

T24-P08 - Effectiveness of Atlantic Forest restoration projects: An evaluation of regenerating communities in restoration plantings

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The monitoring of forest restoration plantings depends on ecological indicators that allow the evaluation of ecological restoration effectiveness, ensuring biodiversity and ecosystem services' recovery over time. In São Paulo state, the Resolution SMA 32/2014 is an important legal instrument that establishes reference values for ecological indicators considered essential to restorations' success monitoring. We aimed to evaluate two of these indicators, richness and density of the regenerating community, in 10 Atlantic Forest restoration plantings, based on reference values endorsed by the Resolution for 10 years-old restorations. Within each site, we registered and identified all individuals with DBH <5 cm and 0.5 m height on four transects (100 m² each). Six restoration plantings showed richness >20 (24±4) and density >2000/ha (2817±435), values considered adequate for the restorations' age. None of the areas presented critical values according to the legal document. Despite the positive outcomes, we identified evidences of degradation by cattle presence in some sites. For these communities, richness and density amplitudes (12-31; 1625-3175/ha, respectively) were greater in comparison to the areas without cattle presence (23-30; 2250-3200/ha, respectively), evidencing the need of forest management to hold more solid restoration outcomes. We conclude that, although the 10 years-old restorations reached adequate values, the effective isolation of degradation factors, might support greater regenerating communities' richness and density, safeguarding forests successional trajectories and perpetuation. We highlight the importance of legal instruments to ensure the monitoring of ongoing restorations, assisting forest management actions to restore biodiversity and ecological processes in human-modified landscapes.

T24-P09 - Green manures as improvement`s technique for weed control, nutrients cycling and microclimate in Atlantic Forest restoration areas

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Restored areas perpetuation is intrinsically connected with the ecological succession process. In degraded areas, perpetuation is limited by weed competition, microclimate variation and soil properties adverse to the species establishment. We evaluated how green manure management, intercropped with tree species, can assist ecological succession. This experiment was done as split plot based on a randomized complete block design, carried out at Piracicaba, São Paulo State, Brazil. The main plot was (Control, *Crotalaria juncea*, *Crotalaria spectabilis*, *Canavalia ensiformis*, *Cajanus cajan*, *Cajanus cajan* "dwarf", *Pennisetum americanum*, *Stylosanthes* sp and two mixed) and subplots were management (cut and uncut). Covering soil rate, dry biomass and weed biomass were used as evaluation parameters before cutting. Recolonized weed biomass, decomposition rate, availability of nutrients, air temperature and air relative humidity were used as evaluation parameters after cutting. *C. cajan*, in general, stood out due to dry biomass, weed control, availability of nutrient and microclimate regulation. Due a longer life cycle, *C. cajan*, inhibited weed regrowth. Dry biomass, on 115th day of planting, was 8.84t/ha; 50% of this mass, exposed to the soil, decomposed in 100 days, making available 42.4Kg N, 3.2Kg P and 38.5Kg K per hectare. In comparison to the cut subplots, average temperatures were 2.16 °C lower and average relative humidity 9.42% greater, after 16 months of intercropping with *C. cajan*. The results indicate that once silvicultural practices are adopted, as weeding around and fertilization seedlings in field, intercropping with semi perennial species, uncut, can improve the first requirements needed for ecological succession.

T24-P10 - Functional restoration: litterfall and nutrient in a biodiverse system

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Litterfall can be used as an indicator of ecological restoration and is a fundamental process for nutrients cycling, and soil fertility in tropical forests. In addition, it contributes to carbon fluxes into the atmosphere in the context of global climate change discussion. In this work, the objective was to evaluate the early input of organic matters and nutrients of a biodiverse restoration model compared to natural forests. At 5 years a restoration (2.7 ha) in the dense-diverse-functional model (DDF), with 142 species and high plant density was compared to five fragments of Semideciduous Atlantic Forest in Sorocaba, Brazil. The litterfall sampling was carried out in 54 conical collectors distributed in six plots (500 m²). All samples were classified in leaves (FF), branches (FR branches and peels), and reproductive structures (FRF flowers, fruits and seeds) and after desiccated to establish the mass of dry matter. Leaf fraction showed greater contribution of litter (77%) with an input of nutrients C > N > Ca > K > Mg > P in the DDF system. Fragments produced 7243 kg.ha⁻¹ and DDF 6225 kg.ha⁻¹. Despite the early stage of DDF, there was a significant contribution of litter and nutrients, similar to others older restorations, indicating the potential of the model to restore this ecological function in a short time.

T24-P11 - Assessing restoration projects success: Contributions for São Paulo state legal framework Resolution SMA 32/2014

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Success of ecosystem restoration projects is conditioned to achievement of minimum levels of complexity that guarantee ecological processes sustainability. According to Resolution SMA 32/2014 the success of restoration should be measured by three ecological indicators: ground cover with native vegetation, density of spontaneously regenerating native plants and number of spontaneously regenerating native plant species. We investigated the applicability of the Resolution in two different restoration systems (direct seeding - DS and high-diversity tree plantation - TP), 19 years after planting in Botucatu, Brazil. The three ecological indicators listed in the Resolution were evaluated, as well as three other vegetation attributes: ground cover by exotic grasses; number of canopy species and percentage of deciduous trees. Both systems were considered restored based on the Resolution reference values (more than 80% of canopy cover, more than 3000 individuals.ha⁻¹ and more than 30 species regenerating). Our results demonstrated that DS system showed high cover by exotic grasses (69%), compared to TP (19%). This difference was explained by the high percentage of deciduous trees in DS (76%) community, compared to TP (36%). The wide canopy opening in DS system results in high dominance of understory invasive grasses that may threaten long term forest self-sustainability. We verified that the method applied to quantify the canopy cover is not ideal to evaluate restoration projects in semideciduous seasonal forests. We suggest that ground cover by exotic grasses should be added as ecological indicator to this normative, contributing to assess the needs of adaptive management practices in restoration process.

T24-P12 - Edaphic fauna as bioindicators with mechanical control treatment in *Bambusa tuldoides*

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The use of edaphic fauna as bioindicators of environmental quality is justified by its sensitivity to environmental changes. We analyzed the effect of the mechanical control (through drag by tractor-mat) of *Bambusa tuldoides* (Poaceae) on the edaphic fauna in the Pampa Biome, Rio Grande do Sul, Brazil. The edaphic fauna was compared in *B. tuldoides* (BT), mechanical control of *B. tuldoides* (MC) and native forest (NT), using 10 traps/treatment. We sampled eight months after mechanical control (summer/2015), and identified the edaphic fauna at the level of order and determined the richness and the Shannon index (H'). NT presented the highest richness, with 1242 individuals distributed in 12 orders, and Hymenoptera (421), Coleoptera (296) and Col-

lembola (84) were the most representative orders. BT presented 983 individuals in 12 orders and Hymenoptera (619), Collembola (71) and Coleoptera (43) were the main orders. MC presented 619 individuals in 15 orders, and the main orders were Hymenoptera (218), Collembola (150) and Coleoptera (66). About diversity, MC and NT showed very similar H' (1.82 and 1.81, respectively). BT showed $H'=1.33$. In MC, the revolving of the soil, with the incorporation of plant material may have contributed to the maintenance of edaphic fauna in the site after the drag. In BT, the large amount of leaves from the bamboo may be related to the great richness of the order Hymenoptera. Despite the maintenance of the fauna in MC, studies should be performed aiming at monitoring of the population fluctuation of the edaphic fauna in these environments.

T24-P13 - Are restored riparian forests along hydroelectric reservoirs margins efficient in soil protection against laminar and wave erosions?

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Riparian forests play a fundamental role in the preservation and maintenance of biodiversity and ecological processes. Through the provision of environmental goods and services, they enable the development of various activities that can guaranty human needs and improving the living conditions of populations. One of these environmental services is the soil protection against erosive processes. In the case of hydroelectric reservoirs, the loss of most of the riparian forests during its construction obliges the mandatory implementation of forests restoration projects. In the Volta Grande reservoir (Minas Gerais, Brazil), laminar erosion and wave erosion are predominant among erosive processes. In order to evaluate the efficiency of reforestation projects, six areas were selected for monitoring laminar erosion (exposed soil, sugarcane plantation, native forest, two riparian forests with more than 20 years of reforestation and one with 10 years) and four areas for wave erosion monitoring (grassland, native forest and two riparian forests, one with more than 20 years of reforestation and another with 10 years). The results showed the effectiveness of these restoration projects in the protection of reservoir banks, with a reduction of up to 40% in laminar and wave erosions. The function of reducing soil erosion, provided by the presence of riparian forest, not only guarantees soil stability, but also acts as a physical barrier, reducing the amount of sediments that enters the reservoir, reducing its sedimentation and consequent loss in its generating capacity.

T24-P14 - Are the SER Primer attributes and socioeconomic variables being monitored sufficiently in Latin America?

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Although ecological restoration (ER) is being adopted worldwide as a means of mitigation to climate change, ER projects are rarely monitored properly due to limitations in time, labour, or budget. Here we present the results of a meta-analysis conducted from a literature review about ecological and socioeconomic indicators that are being used for monitoring ER in Latin America. From the 60 publications retained, only 20% included monitoring per se; 80% reported on chronosequence studies, based on comparisons among areas with differing times since ER was initiated. Ecological indicators were evaluated in 88% of the papers (53 papers), while only 7 papers measured socioeconomic indicators. Regarding the SER Primer attributes of restored ecosystems, we only found indicators measuring SER Attributes 1-6, with SER Primer attribute 1, species assemblages predominating (60%), followed by physical conditions (40%) and ecological functions (38%). Brazil was the country where most monitoring is being carried out (51% of the papers), and rainforest (33%) and dry forest (26%) were the ecosystem types where ER was most frequently monitored. Highly vulnerable ecosystems such as mangroves and paramos were underestimated. Attributes related to ecosystem stability or to governance and education of communities, were not being monitored at all in the Latin American ER projects captured in this survey. More real long-term monitoring, instead of chronosequences, are needed, especially where socioeconomic implications of ER are a top priority.

T24-P15 - Using an integrated framework to assess multiple objective habitat restoration projects

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Nowadays, ecological restoration projects involve several stakeholders and target multiple objectives. Summarizing the project success taking all its dimensions into account may therefore not be easy to achieve. The ASPIRE framework (Appraising the Success of Project In ecological Restoration and Ecological engineering) has been developed specifically to address this issue. The ultimate success score of the project is a weighted mean of objective scores; the objective scores are weighted means of their variable scores and the variable scores are calculated through a utility function based on the variable values relative to their references. Using an integrated framework such as ASPIRE helps project stakeholders to accurately define measurable objectives. The ASPIRE framework will be use in the forthcoming years to assess the success of several wetland habitat restoration in the French and Italian Alps. These projects have several objectives, such as restoring biodiversity, decreasing exotic invasive species or providing ecosystem services. The poster will present how the various stakeholders define and weigh their objectives, which and how variables are measured and how the ASPIRE graphical and numerical outputs can be interpreted.

T24-P16 - Exploring successful ecological restoration in rural settlements of the Lower Araguaia, Brazilian Amazon

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Successful ecological restoration must consider multiple interactions in order to provide benefits to both people and biodiversity. Stakeholders' perceptions are a crucial element in identifying factors influencing their willingness to be involved in restoration. This study aimed to assess various stakeholders' perceptions about successful restoration of the Lower Araguaia in the Brazilian Amazon. It evaluated a project in which 233 hectares were restored by 105 households from 2002 to 2016 in two rural settlements of the São Félix do Araguaia region, Brazilian Amazon. Data was collected by four homogenous focus groups in June 2016, encompassing two community engaged (n= 11 and 28 farmers); NGO project intervention (n= 5 staff); partners (n= 4 leaders of organization). These stakeholders were encouraged to identify, describe, and categorise factors of successful ecological restoration. Overall, 170 factors of success were identified, of which most (40%) were related to technical aspects, such as training and orientation, planting techniques, and weed control. However, almost two-thirds of the identified factors involved other dimensions, encompassing social-political, economic, physical, human, and natural factors. Among stakeholders, NGO staff identified the highest proportion of strengths (34%) and opportunities (25%). While, farmers from one of the settlements reported the biggest proportion of threats (42%), of which more than half were socio-political issues, such as organization, participation, and multi-sectoral engagement (including healthcare and education systems). Thus, actors' perceptions vary in relations to their role and position in the restoration processes. Successful programs in rural communities require aspects beyond restoration techniques to promote multiple-stakeholders participation.

T24-P17 - Soil arthropod fauna as bioindicator in bamboo-dominated forest submitted to chemical control

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The soil arthropod groups are efficient to indicate environmental quality levels, collaborating in many ecological processes. It was analyzed soil arthropods in bamboo-dominated forest remnant (*Bambusa tuldoides* Munro) submitted to herbicide control treatment (Tibutiuron, 30 kg/ha), in Rio Grande do Sul state, Southern Brazil. Chemical control of bamboos (QC), bamboo-dominated area (BA) and native forest (NF) were compared with sampling performed three months after chemical control application. The sum of arthropods in each treatment was 849, 983, 1242, respectively, in QC, BA and NF. The most abundant orders for QC were Hymenoptera (245), Coleoptera (138) and Acari (127). In BA, the most abundant orders were Hymenoptera (619), Diptera (108) and Coleoptera (71). Hymenoptera (421), Coleoptera (296) and Collembola (182) predominated in NF. Collembola abundance in QC was 122 and in BA was 44 individuals. H' values (Shannon diversity index) were low (QC=1,894; NF=1,787; BA=1,332). The major abun-

dance to Collembola Order revealed better environmental quality in NF. The high number of Hymenoptera is common in sandy soils, like the study sites. The biomass input from the desiccation by chemical control may explain the similar H' values between QC and NF. With the biomass decomposition, a gradual succession can be expected, with dominance by generalist groups, such as Hymenoptera and Coleoptera. Therefore, soil arthropod fauna was an effective bioindicator of differences among habitats and environmental modifications caused by the bamboos.

T24-P18 - Fruit feeding butterflies as ecological indicators of mining restoration in the Amazon forest

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Feeding-fruit butterflies (FFB) are a key group for monitoring changes in the landscape. In the 220,000 hectares Jamari National Forest, a multiple use protected area, about 860 ha of its area is now being restored from degradation by cassiterite mining. We evaluated differences in FFB abundance at different forest recovery levels, ranging from areas with primary forest to recent restoration. We compared the abundance and similarity of FFB genus and tribes by using standardized sampling across the restoration gradient. The sampling effort was 2,592 trap-day, with a total 1,783 FFB captured. Genus richness and abundance were higher in areas under restoration than in secondary and primary forests, with 39, 29 and 22 genera, and 1,256, 324 and 199 individuals respectively. In areas under restoration, the tribes Ageroniini and Epiphilini had the highest frequency of occurrence, with 97% and 96%, respectively. Morphini and Brassolini were the most frequent in both secondary and primary forests with 63% and 61% of the total, respectively. Two genus, Hamadryas and Paryphithimoides, were identified as consistent indicators of low level restoration areas. The sampling protocol used was simple and had low cost. In addition, the identification of FFB at genus level was possible for non-specialists. By monitoring the proportion and frequency of FFB occurrence, we can make robust inferences of restoration progress of mined areas. Our results reinforce the use of FFB as indicators for forest restoration assessment and monitoring.

T24-P19 - Partition of diversity of natural regeneration in an area in forest restoration process

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The goal of forest restoration is the recovery of biologically viable forests that do not depend on constant human interventions. For this reason, the species that will compose the forest restoration projects should be carefully chosen, considering that the distinct ecological filters created by these species can direct the evolutionary regeneration process. In this sense, the objective is to evaluate the partition of the diversity of natural regeneration in areas in process of restoration. The alpha component is expected to explain the diversity of the regeneration stratum. Our study was conducted in an area in restoration process in Reserva Natural Vale, Espírito Santo, Brazil. The planting was carried out in three treatments with different richness (29, 58, and 114 species planted). An additive partitioning of diversity was used to verify the contribution of diversity alpha (richness in each treatment) and beta (richness among treatments) in diversity gamma (accumulated richness throughout the area) of the plant's community in regeneration. The partition of diversity revealed that the species of natural regeneration of each treatment (alpha) represents 50% of the total richness of diversity gamma. Diversity beta also contributed with 50% of the total richness. In the study area both the heterogeneity of the habitat created by different treatments and how much each treatment has also equally contributed to diversity. Based on the results we suggest that at the time of planting it is important to choose a set of species to facilitate regeneration and not consider only the number of species used.

T24-P20 - Biological soil crusts as ecosystem engineers indicate desert ecosystems health in arid desert regions of China

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Biological soil crusts (BSCs) are highly specialized soil-surface consortia of cyanobacteria, green algae, lichens, mosses and other organisms. Little attention has been given to their contribution to desert ecosystem health. We conducted a 10-year study on BSCs in Shapotou of the Ningxia Hui Autonomous Region at the southeastern edge of the Tengger Desert in northern China (37°32' N and 105°02' E). The results of study showed that cyanobacterial-algal crusts showed the highest nitrogenase activity (16.6 mmol m⁻² h⁻¹), followed by lichen crusts (6.9 mmol m⁻² h⁻¹), and moss crusts (2.6 mmol m⁻² h⁻¹). The annual carbon fixation was 11.36 g C m⁻² yr⁻¹ for cyanobacteria-algae dominated crusts and 26.75 g C m⁻² yr⁻¹ for lichen-moss dominated crusts. The colonization and development of BSCs significantly enhanced nematode diversity in topsoil. Nematode abundances, generic richness, H, MI, EI and SI were positively correlated with crust ages. BSCs increased soil microbial biomass (biomass C and N), microbial phospholipid fatty acid (PLFA) concentrations and the ratio of fungal to bacterial PLFAs. BSCs improved the soil water availability of the shallow layer by enhancing the topsoil water-holding capacity, which occurred due to increased silt and clay and decreased surface evaporation via absorption by cryptogams. These findings suggest that the protection and maintaining suitable cover of BSCs must be considered when implementing large-scale restoration projects in arid desert regions.

T24-P21 - System of monitoring and management of restoration programs and projects

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Monitoring is a fundamental step of successful ecological restoration efforts. However, it is also a costly process and implementation is slow, making it difficult for monitoring to achieve satisfactory results. One of the challenges of taking restoration to scale is the creation and application of tools that help monitor the quality of areas undergoing restoration. Consequently, the Nature Conservancy (TNC), in partnership with the Pacto pela Restauração da Mata Atlântica (Pact for the Restoration of the Atlantic Forest - PACTO), developed a tool called the Restoration Monitoring Application. It integrates with the information manager of TNC's Geo web system used in restoration projects to collect monitoring data. The web system is meant to support project management, provide greater security, expedite data transmission and allow the sharing of project information. The system has the following technical characteristics: LINUX open operating system; PostgreSQL / PostGIS relational databases; and PHYTON. The Monitoring Restoration Application (Android system) is integrated to the system via WEB service. The application facilitates access to the plots in the field through digital mapping, data download, data collection in offline mode, and upload to the system, which receives the raw information and generates analyses and reports. These features tend to reduce costs during monitoring and provide greater data reliability, optimization of projects' time usage, and improved processes. The application for monitoring data collection is free and can be replicated for large-scale monitoring in Brazil.

T24-P22 - Evaluation of coastal swamp forest restoration 18 years after planting

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Swamp forests in the coastal sandy plains in the city of Rio de Janeiro have been in restoration process for around 18 years. In these forests, flooding is originated by the rising of the water table above soil surface. The various adverse effects of flooding on plants are magnified in swamps, leading to the accumulation of deleterious chemical elements. Therefore, restoration of degraded swamps requires strong human interference. The planting of 22 native species was set in 1998 in degraded swamps invaded by exotic grasses and sedges, and since 2012 some ecological indicators have been investigated. Density (4,950 ind.ha⁻¹), species

richness (16 species), Shannon diversity index of the arboreal community (2.27) and density of regeneration community (40.9 ind.m⁻²) in reference area were greater than in planting areas (2,975 ind.ha⁻¹, 8 species, 1.42 and 17.3 ind.m⁻²). The species richness (17 species) and the diversity of regeneration community (2.17) in planting areas were similar to the ones in the reference area (17 species and 2.16). The seed rain in planting areas was 10,245,000 seeds.ha⁻¹.yr⁻¹, from 21.7 species, and 8,393,333 seeds.ha⁻¹.yr⁻¹, from 25 species, in reference area. The litter fall in planting areas (11.07 Mg.ha⁻¹.yr⁻¹) was greater than in reference area (7.87 Mg.ha⁻¹.yr⁻¹). The analysis of foliar litter decomposition rates over 120 days in planting and reference areas showed that there were no differences between them. These results indicate that the swamp forest in restoration process is following a satisfactory successional trajectory.

T24-P23 - Can Atlantic Forest remnants be used as reference ecosystems? Insights from biomass estimates

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Anthropogenic disturbance, such as timber extraction and hunting, add up to fragmentation effects and can lead to deep changes in forest ecosystems. One key question is whether those fragments can serve as reference for ecological restoration. Aboveground biomass (AGB) is a common indicator of carbon sequestration, an important ecosystem service for climate mitigation. Whenever forest remnants suffered any disturbance, such as timber extraction, AGB can be reduced, and the recovery will take place under the rule of edge and other fragmentation effects, leading AGB to stabilize in a different level. We estimated the AGB in six Atlantic Forest remnants that have been used as reference ecosystems for forest restoration in the north of the Paraná state, Brazil. Three of them suffered timber extraction 40 years ago, and were called “exploited” and compared with the non-exploited forests. AGB estimates were done using allometric equations and included trees with DBH from 2.5 cm. Non-exploited forests showed an average AGB of 384 Mg ha⁻¹, higher ($p=0.007$) than exploited forests, which averaged 204 Mg ha⁻¹. These results suggest that the remnants which were submitted to timber extraction did not recover biomass to the expected level of the regional forests even after 40 years, and thus their role as references for ecological restoration should be challenged with regard to the carbon stocks. However, frequently these exploited forests are the best vegetation remnants in the neighborhood of restoration sites and therefore are the only references for species composition and other plant assemblage features.

Natural regeneration /resilience/ passive restoration

T10-P01 - Resilience of Mediterranean forest to drought: implication for restoration

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There are two common definitions of ecosystem resilience which are widely used. Firstly, time taken by an ecosystem to recover its ecological attributes (e.g. structure, composition, function). Second, the magnitude of the disturbance that an ecosystem can absorb and recovering its attributes. We combine these two ideas as a different metric of resilience, measuring the variation of the curve slope of recovery after different drought magnitude. We measure the resilience of forest to the drought, represented as the time taken (NDVI curve slope) for the ecosystem to recover its pre disturbance values of the Normalized Difference Vegetation Index (NDVI) like a proxy of its ecological attributes. We compare the differences in this response between old growth and secondary forests in a drought disturbance gradient. We use temporal series of MODIS NDVI to measure the rate of recovery after a climatic disturbance occurred between 1992-2000, quantified as the number of days in the last four year without rain. We found that the old growth Mediterranean forest have a higher resilience than the secondary forests, expressed in a lower rate of decrease of the slope of NDVI curve as a function of the increase of the magnitude of the disturbance. In Mediterranean Chilean forest more than 90% is secondary forest. These results suggest the urgent need to restore these secondary forests to increase the forest resilience to drought periods and try to understand what ecological attributes are associated with its resilience.

T10-P02 - Seed bank in an abandoned pasture of a Cerrado-Pantanal ecotone area

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In abandoned pastures, initial regeneration confront with many obstacles such as competition with exotic grasses, soil compaction and reduction of the diaspores arrival, which can affect the emergence, abundance and richness of propagules. The aim of this work is to characterize the seed bank composition in an abandoned pasture. This pasture have been abandoned for three years, located in the municipality of Aquidauana, Mato do Grosso do Sul State, Brazil, and it is a Cerrado-Pantanal ecotone region. We collected eighty 20 x 20 x 5 cm samples of seed bank identified, quantified and classified according to growth habit, dispersal syndromes, successional groups and size classes. We identified 62 species from 47 genera distributed in 25 families. The richest family was Fabaceae, with 12 species. We found also many exotic species from Poaceae and Cyperaceae families. Forty three percent of the diaspora had from 0.5 mm to 1 cm, 48% from 2 to 5 cm and 9% from 6 to 10 cm.. For growth habits, herbaceous and shrubs were 79% of total, trees were 13% and climbers 8%. The dispersal syndromes found were autocoria (48%), zoocoria (31%) and anemocoria (21%). The pattern of composition is typical of regenerating areas, with high proportion of non-woody and pioneer plants that are colonizers of disturbed areas.

T10-P03 - Using the process whereby natural forest species invade stands of introduced species to rehabilitate invader plant stands to natural forest

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Planted and naturalized stands of introduced species can be manipulated, not cleared, to rehabilitate natural forest diversity and processes, while providing useful income-generating products and removing the invaders from the system. We clear invader plant stands to plant native tree species, all at great costs, to rehabilitate natural forest, i.e. ignoring the natural succession process. This poster will show how natural forest species from small forest patches (<3 ha total size) invaded a 90-ha stand of the invasive Black wattle, *Acacia mearnsii*, over a distance of 3.1 ha at Swellendam near Cape Town, South Africa. In total, 329 forest species clusters established across the wattle stand: more large clusters closer to and more smaller clusters further away from natural forest patches. The 28 recorded forest species (of a potential 40 species) included 79% tree and 21% shrub species, with mostly larger fleshy fruit and softer small seeds, dispersed by mostly birds and baboons. Maturing forest trees within developing clusters in the wattle stand became a source for forest regeneration away from the clusters, showing different expansion patterns. Four sets of fenced-undefenced plots in the wattle stand showed how livestock, antelope and rodents delayed successful establishment of regenerating forest species with >12 years. This study supported the approach to selectively manipulate invader plant stands in the natural forest environment rather than clearing such invasive species stands, to use the natural succession process rather than planting, and to protect developing seedlings against browsing by stacking invader plant debris around establishing forest seedlings.

T10-P04 - The inverse relationship between lianas density and natural regeneration can inform adaptive management to restore degraded tropical forest fragments

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Due to the historical process of exploration and land use conversion in tropical forests some of these regions are highly fragmented and the remaining vegetation under constant pressure. The increase in frequency and intensity of disturbance in small forest fragments can cause an unbalanced proliferation of climbing plants that end up contributing to hinder forest succession by suppressing natural regeneration and acting as biological filters to seeds arrival. Demand for solving problems related to the adaptive management of lianas as a tool for forest fragments restoration has increasingly risen. We have analyzed the density of natural regeneration in a 14 ha semideciduous forest fragment in the interior of SP state and its correlations with liana's density, diameter, and tree's biomass. Larger diameter lianas are commonly associated with old forests as well as a greater tree biomass and natural regeneration. We predict that high densities of natural regeneration occur within forest patches with larger diameter lianas and higher tree's biomass. We used an AIC model selection using the variables liana density, liana diameter, and trees biomass as predictors of natural regeneration density. The most parsimonious model explaining the natural regeneration density showed a negative slope for liana density and positive for trees biomass. Thus, high density of lianas allied to low tree biomass may show lower densities of natural regeneration and therefore need to be the focus for the adaptive management aiming to restore and increase the forest succession pace and canopy recovery in highly disturbed forest fragments.

T10-P05 - Is natural regeneration alone enough to restore old abandoned pastures near forest fragments?

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The use of natural regeneration in tropical forest restoration has been increasingly recognized as the primary large-scale alternative for initiating and accelerating restoration at low cost. Despite this expectation, the effective use of natural regeneration involves great complexity and unpredictability, and the premise that pastures close to forests will be easy, quick and inexpen-

sive to restore must be tested. This study aimed to evaluate the ecological feasibility of using natural regeneration alone to grow biodiverse and sustainable forest communities after pastures are abandoned near forest fragments. We established four adjacent blocks of abandoned pastures close to preserved forest fragments containing two plots each (with or without natural regeneration assistance - grass removal and fertilization) in Sertãozinho, SP, Brazil. During three years, we regularly recorded survival, height, diameter at ground level and crown diameter of shrubs and trees of the regenerating community higher than 0.5 m. So far, our results show that regeneration density largely varies between blocks (13-655 individuals per hectare) and that animal-dispersed shrub species play a major role regarding the initial colonization of abandoned pastures since the regenerating community has low species richness (10 species total) and trees represent only 8.2% of individuals, being the community dominated by shrubs, especially *Solanum paniculatum* (near 80% of individuals). We concluded that natural regeneration alone will result in low density of tree species and low plant species richness, if no additional intervention is applied to foster the recovery of the historical vegetation.

T10-P06 - Resprouting as a restoration mechanism for montane rainforest trees after fire

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Climate change and fragmentation are increasing the frequency and intensity of forest fires in rainforest regions. Evaluating how forest recovers after fires is important to understand compositional and structural changes in the community and to plan restoration. Resprouting ability and prompt germination of pioneers are common mechanisms of forest regeneration after fires. To test the importance of sprouting, we examined the ability of forest species to resprout comparing burned and unburned areas in montane Atlantic rainforest (Serra do Valentim, lúna, Espírito Santo, Brasil) that was originally burned in 2015. We counted and classified (basal, stem, root sprouting) all individuals with dead aerial parts, in 30 plots (5 x 10m, 2 control, 1 fire, 10 plots each). We compared regeneration due to sprouting with other mechanisms (seed bank and natural regeneration) accessing datas from others projects in the study area. While seed bank was much reduced in the fire plots compared to controls, resprouting in fire plots (but not controls) was very common and persistent in the burned area, which suggests that recovery can sometimes be rapid following disturbance. We emphasize that the very common families Rubiaceae and Melastomataceae (understory), Clusiaceae, Lauraceae and Myrtaceae all often resprout. Thus, resprouting is important for natural regeneration of montane rainforests after fire, but seed dispersal and seed bank contribute with pioneer species, essential for reassembly. However, species richness is reduced significantly, thus vulnerable species must be seeded if they do not arrive by seed rain from surrounding forests.

T10-P07 - Invasive grasses as biotic filters for the establishment of ecological corridors by passive restoration in cerrado vegetation

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The design of ecological corridors aims at decreasing habitat fragmentation effects by reconnecting different patches, facilitating animal flow, seed dispersal and increasing vegetation cover. However, restoring ecological corridors might be challenging, as it involves deeply modified landscapes, where many biotic and abiotic filters interact, hindering successional processes. We studied the role of exotic grasses as biotic filters for seed germination and seedling establishment in three ecological corridors previously used for eucalyptus monoculture. The study took place in south-center region of São Paulo State, Brazil, and the original vegetation cover was savanna. The corridors were established in 2002, after harvesting the commercial forest and abandonment for passive restoration. We simulated seed rain using 1325 seeds per sq. m of 11 species and tested the effect of removing the grasses on germination and early seedling establishment. We also tested the effect of removing grass competition around 6 established seedlings and saplings of most abundant species that were regenerating. The removal of grass did not enhance the survival and growth of all seedlings and saplings already established in the corridors, and some species showed a negative effect. Similarly, seed germination and seedling establishment were not negatively affected by grass competition, as expected. Seedlings in plots where grasses were removed had lower survival than the control. Individual species showed different respons-

es due to their regeneration strategy (root sprouting ability, seed traits) and interaction with herbivores. Our results indicate that only removing invasive species is not always the best strategy to restore ecological corridors.

T10-P08 - Plant species composition in an abandoned pasture area in the Cerrado-Pantanal ecotone

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Many native species confronts difficulties to regenerate in abandoned pastures. Since limitation in the input of diaspores to even compaction of the soil. We aimed in this study to characterize the floristic composition of an abandoned pasture in regenerating process. The area have 35 ha and is in the Cerrado-Pantanal ecotone region, municipality of Aquidauana, Mato Grosso do Sul State, Brazil. Monthly, from May 2016 to March 2017, we sampled all flowering plants from all growth habits using unsystematic walking method. We collected and identified the species consulting the herbarium CGMS/UFMS, digital herbaria and taxonomists. We identified 67 species of 50 genera, distributed in 26 families. Fabaceae was the richest with 13 species, followed by Annonaceae and Malvaceae with 5. We also found two exotic species of *Brachiaria* formerly used as a pasture by the owner. Most of the species were herbaceous 34%, followed by shrubs, 22%, trees, 20%, sub-shrubs, 13.4%, climbers, 7.4% and palm trees 1.4%. In the successional groups, we found 72% of pioneers 28% of initial and late successional species. The dispersion syndromes were autocoric (45%), zoocoric (31%) and anemocoric (24%). According to our results, the area is in initial regeneration due to high number of pioneers/herbaceous species and low number of trees. Some of the found species can be used in the future for restoration processes.

T10-P09 - In situ seed bank evaluation as first alternative to restore the forest at Isla del Coco National Park, Costa Rica

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Isla del Coco National Park is located in the Eastern Pacific, 300 miles from Costa Rica's mainland. Its tropical moist forest had been degraded by deforestation and by the introduction of feral pigs and white-tailed deer. The deforested area did not recover its native forest. Presently, at the Chatham Bay area, two treatments were established in order to evaluate the seed bank, one treatment consisted on cutting the current invasive vegetation, and the second consisted on ripping off the invasive vegetation, both in order to stimulate sprouting of the seed bank. The treatments were established within an exclusion fence. The Braun-Blanquet Method was applied to evaluate species composition and site cover. After six months, the sites recovered their vegetation, however, the composition and vegetation structure were different to the previous one; the new cover is dominated by *Paspalum conjugatum*. The presence of tree species was expected; regeneration of *Cecropia pittieri* was found. *Entada gigas*, a fast-growing liana, and *Hypolytrum amplum* which were dominant species of the removed cover are present by sprout in low percentages. *E. gigas* invades the treatment area from the edge of the original cover. The results suggest a seed bank rich in grass species, which would allow the establishment of fast growing tree species such as *C. pittieri*. As a next step, control is necessary to favor regeneration of tree species, due to the risk of being overtaken by the original vegetative cover, principally for *E. gigas*.

T10-P10 - Livestock removal is not enough to recover functional diversity in arid ecosystems of the Patagonian Monte (Argentina).

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Sheep grazing induces the replacement of preferred plant species with low defences by others well defended against herbivory, affecting the variance of trait distributions related to resource capture and utilization within plant communities ('functional diversity'). High functional diversity may reflect high species complementarity in resource use, improving ecosystem functioning. We analysed whether the removal of domestic herbivores (disturbance agent) enhances the functional diversity of traits related to light capture in Patagonian Monte rangelands. We selected two contrasting sites in relation to grazing disturbance: La Elvira (EL) which has been grazed by sheep from the beginning of the past century until present with a stocking rate of 0.11-0.14 sheep/ha and La Esperanza (ES) subjected to the same grazing history but until 2003, when livestock was removed. At each site, we identified two areas with contrasting signs of grazing disturbance (high and low grazing impact), and we assessed the plant cover and the functional diversity of plant height, specific leaf area and N concentration in green leaves in August 2010. Plant cover was higher in ES (past grazing) than in EL (past and present grazing), and the difference between areas (low and high grazing impact) was higher in ES than EL. Functional diversity did not vary between sites being higher at areas with low than high grazing disturbance. Accordingly, changes in functional diversity induced by grazing persisted after livestock removal despite of increased plant cover. In conclusion, short-medium term livestock exclusion is not enough to restore functional diversity in the Patagonian Monte.

T10-P11 - Seed versus vegetative propagation: What is the greatest contribution to the maintenance of the grasslands physiognomies in South of Brazil?

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Natural grasslands of southern Brazil are under strong anthropogenic pressure, being completely eliminated in many regions, and they are still susceptible to forest expansion, since the current climate is favorable for it. This work sought to verify the role of seed rain (SR), soil seed bank (SSB) and vegetative structures (VS) for the maintenance of the grassland physiognomies in South of Brazil. We carried out this study in Vila Velha Park, Parana State (25°12'34"-25°15'35"S and 49°58'04"-50°03'37"W), in different grasslands physiognomies: dry, wet and rocky. In each of the 90 plots (1x1m) delimited for the phytosociological study, 90 seed collectors (20x20x5cm) were installed (collected monthly for two years) and 90 soil samples of the same size were collected (collected in each season of the year). A total of 384 species were sampled, but most were found only for established vegetation (71%), presenting low floristic similarity. In addition, when correlations abundance matrices of the SR x SSB x VS were evaluated, only wet grassland was significant to SSB and vegetation. The association of the results found in this study leads us to conclude that both SR and SSB diaspores in the grassland physiognomies are likely to contribute to vegetation regeneration because they play a fundamental role as a source of recruitment of new individuals. However, for many species the main regeneration strategy is vegetative propagation, since frequent burning have contributed to the rapid development of plants and, consequently, to the maintenance of the grasslands communities.

T10-P12 - Towards restoration of a fragmented tropical rain forest: potential of remnant trees in pastures of Sierra de Los Tuxtlas, Veracruz, Mexico

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Deforestation has generated a fragmented landscape in tropical rainforests that immobilizes and isolates biological diversity. A conservation strategy consists in facilitating species transit across pastures surrounding forest fragments. In such fields the presence of remnant solitary trees as landscape correcting elements stands out. A floristic and dendrometric arboreal species survey was carried out: diameter at breast height (DBH), total height (TH), canopy diameter (CD) and first ramification height (FRH) were recorded. A total of 238 individuals were identified among which 151 (68 species) were found in Tebanca (TB) and 132 (36 species) were found in Balzapote (BZ). The presence of *Ficus* sp. (Moraceae) stands out with 13% of the individuals at TB, while *Ceiba pentandra* (Malvaceae) was the most representative species at BZ (11%). *Cedrela odorata* (Meliaceae), *Platymiscium pinnatum* (Leguminosae) and *Spondias radlkoferi* (Anacardiaceae) were present at both sites. Dendrometric values are described and compared for both sites with maximum values of DBH: 352cm, TH: 47m; CD: 40m and FRH: 35m. A generalized linear model revealed that the presence of a tree larger than the median DBH (72cm) depends mainly on the CD. A nucleation technique is proposed as a restoration technique, suggesting also the use of *Cedrela odorata*, *Spondias radlkoferi*, *Ceiba pentandra*, *Platymiscium pinnatum* and some *Ficus* species. This knowledge would be transferred to local inhabitants as the main beneficiaries of the main ecosystemic services that the largest solitary trees offer.

T10-P13 - Nature's engineers successfully restored the natural processes in a degraded marsh

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The Prejmer marsh, located in Brasov (Romania) has a long history and a high biodiversity, however the surface of the marsh has been reduced starting from 70's, due to agricultural practices. In this Natura 2000 site we have started a restoration project 5 years ago, the first measure was to stop the uncontrolled grazing and to build a green fence in the surrounding area of the remaining marsh, in order to protect it. After few months, taking advantages of the protected area, a pair of European beavers (*Castor fiber*) has appeared. They started to build 2 small dams, and by the next fall the water flow and level already started to change. With our monitoring system, and together with botanist, environmentalists and habitat specialist we agree not to intervene, and to leave them there for the next year. After the plant monitoring in the spring, we found out that the numbers of *Liparis loeselli* (1 individual in the first year), and *Ligularia sibirica* (10 individuals in the first) has started to grow, most likely due to the fact that water level has increased from the previous year determining an awakening of the long-dormant seeds from the soil. After 4 years of monitoring (of water, soil, plants and animals), the marsh surface, has increased from 1ha in the first year, to 6ha nowadays. Nature's engineers successfully restored the natural processes in the marsh, in a simple, fast and efficient way, teaching us that nature can sometimes be the best conservationist.

T10-P14 - A critique of passive restoration as a method to tropical forest regeneration under Eucalyptus plantations

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Being an exotic species, the eradication of *Eucalyptus* spp. in conservation units in Brazil is a usual method, despite several studies which have reported that these forest plantations can catalyze the natural regeneration. Conversely, many conservation unit managers are opting not to eradicate these plantations, relying instead on the passive restoration of these areas to avoid negative impacts on the previously established flora. In order to assess if passive restoration is in fact the best way to restore these areas, we have evaluated the natural regeneration dynamics of a tropical rainforest under 500 ha of *Eucalyptus urophylla* planted between 1960-1963 at Serra do Mar State Park (45° 08' 12" W, 23° 21' 04" S). Four blocks (10 plots of 15 x 7.5 m per block) were installed and all trees registered (DBH \geq 3.18 cm) in 1993 and 2016. In this 23-year period, we noticed an increase in species

richness (64 to 145). However, the forest structure was below expectations for a 50-year-old forest: the total density was high (3,187 ind./ha) and the basal area (21.49 m²) was much lower than nearby reference ecosystems of the same age, considering that the *E. urophylla* population prevailed (61% of the total). Only understory species showed high importance values, in majority resident late secondary species, pollinated and dispersed by animals. We recommend that active restoration practices are taken with gradual suppression of the *Eucalyptus* so that native species can form the canopy without too much harm to the diverse understory already established.

T10-P15 - Ecological Restoration of dry forest in Colombia through natural regeneration management of *Cordia alliodora* neotropical tree

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Natural regeneration has been reported as a low cost strategy to restore tropical forests, but sometimes it needs management interventions. This study was carried out in an early successional tropical dry forest (40 ha) 10 years old, established after a forest fire, in the Magdalena river valley, in central Colombia, where *Cordia alliodora*, a valuable tree species, is abundant. Our goal was to improve the development of natural regeneration and the recovery of floristic diversity in the burned area. Trees with DBH from 5.0 cm were measured in 20 transects of 0.1 ha. In addition, 45 permanent plots of 25 m² were established to monitor the dynamics of natural regeneration and habitat structure. Thinning and liana cut were carried out to improve the performance of *C. alliodora* trees by reducing forest density. *Cordia alliodora* presented more than 50% of individuals and showed gregarious patterns within the forest. As a consequence of thinning and liana cut, the recruitment rate of *C. alliodora* exceeded mortality by more than 60%. The average rate of stem growth exceeded 1.8 cm.year⁻¹. The environmental requirements for the successful establishment of the young trees were 40% light intensity, 55% crown cover and 30% soil moisture. The density of species expressed by the Margalef index increased from 4.7 to 5.5. The strategies of liana cut and thinning of *C. alliodora* populations improved the structure, functioning and diversity of these early successional forests, stimulating local people to conserve these forests instead of changing land use.

T10-P16 - Interventions for ecological restoration: eliminating barriers to accelerate forest restoration in southern Amazonia

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Livestock ranching is one of the main threats to the tropical rainforest, and it promotes deforestation, loss of biodiversity, soil degradation, and introduction of exotic grasses such as *Urochloa decumbens*. Fighting this exotic grass and redressing the lack of propagules are the main challenges to the restoration of abandoned pastures in the Amazon. In our experiment, we tested growing levels of intervention to break these barriers, in the region of Porto Velho, state of Rondonia, Brazil, in the riparian zone of the Madeira River. We tested grass removal, direct seeding of pioneer species, seeding planting, and a combination of direct seeding and seedling planting. There was a significant difference between treatments and the control regarding density of individuals and species, as well as a higher recruitment of individuals in the treatments with grass removal, which indicated that the exclusion of the exotic grass was the most efficient strategy to the restoration success. Direct seeding promoted an increase in individual density, while seedling planting added to the diversity right in the beginning of the restoration process. Tree cover reached 50% after a year of study. Our results show that direct seeding of pioneer species combined with exotic grass control can be a low cost alternative to the ecological restoration of fallow pastures in the Amazon, favoring ecological succession in these areas.

T10-P17 - Regeneration strata within two geomorphological compartments in the Araucaria riparian forest, Jotuva River, Carambeí (PR), South Brazil

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Araucaria riparian forests lack information about their regeneration strata. These communities were adapted to the environmental heterogeneity subject both to flooding as to sedimentation, so we studied the regeneration strata of an undisturbed riparian forest under two geomorphological conditions. We obtained frequency and abundance of 664 living seedlings between 30-150 cm height and ≥ 5 cm DBH within 80 1X1 m plots. The mesophilic area is compound by Litholic Leptosols with groundwater level higher than 1m deep, and 8-20% declivity. We observed density of 56,500 ind./ha, 41 taxa, 19 families, $H' = 3.27$ nat/ind., and $J = 0.83$. The species which higher importance according to the number of individuals, frequency, and density, were *Sebastiania commersoniana* (Baill.) L.B.Sm. & Downs, *Casearia decandra* Jacq., *Rudgea parquoides* (Cham.) Müll. Arg., and *Myrciaria delicatula* (DC.) O.Berg. The hygrophilic area is compound by Fluvic Leptosols with groundwater level lesser than 1m deep, and 0-3% declivity. We observed density of 96,900 ind./ha, 36 taxa, 20 families, $H' = 3.10$ nat/ind., and $J = 0.77$. The species which higher importance according to the number of individuals, frequency, and density were *Hennecartia omphalandra* Poiss., *Myrsine umbellata* Mart., *Symplocos uniflora* (Pohl) Benth., and *Myrciaria delicatula*. The species distribution differs ($p = 0.02$) according to their adaptation to the groundwater level and soil type. Water saturation leads to lesser specific diversity and higher individual density.

T10-P18 - Secondary succession in the Atlantic Forest of southern Brazil: improving identification of reference conditions for ecological restoration

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Deforestation and degradation of the Atlantic Forest have resulted in a fragmented landscape of secondary forests in various stages of succession. Understanding forest recovery presents a major step towards devising sound conservation and restoration actions in this important biodiversity hotspot. We aimed to characterize successional stages and identify key indicator variables that differentiate them during the successional process in the Atlantic Forest of southern Brazil. We established 12 square plots of 1ha, in which we identified and measured all trees with diameter at breast height ≥ 5 cm. Stand age was estimated based on field inspection and interviews with long standing residents and latter assessed with orthophotos from the years of 1952, 1980 and 2001. We sampled a total of 21,155 trees from 276 species. Species density and basal area increased with stand age, whereas stem density significantly decreased across the successional gradient. These forest attributes changed predictably mainly in the early stages of succession. Conversely, species composition was highly variable differing within and among successional stages, but marked by few dominant species. Our results show that secondary forest succession tends towards convergence of structural attributes and divergence of species composition in mature forests. Despite the great variability of species composition, few specialists distinguish secondary forests across the gradient, suggesting that indicator species along with structural attributes contribute to the differentiation of successional stages. We reinforce the complexity of tropical forest succession and the need to include representative samples, assessments of land-use history and accurate identification of species to characterize successional stages.

T10-P19 - Resilient seed bank after fire disturbance of rupestrian grassland in Southeastern Brazil

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The use of soil seed bank can be a strategy to accelerate the process of ecological succession in areas under restoration. This study aimed to characterize the rupestrian grasslands seed bank by analyzing the richness and abundance of emerged seedlings, before and after fire disturbance. The study was conducted at Serra do Cipó (1200 m altitude), Minas Gerais, Brazil. The

seed bank was collected in July 2014 and September 2015, and in September 2014 a fire occurred in the study area. Samples composed of litter and soil (0-5 cm) were collected in 13 plots (100m²), placed in plastic pots under greenhouse conditions, and monitored for 12 weeks. To verify differences of emerged seedlings, a Variance Analysis and Tukey test were performed. The richness ($p < 0.05$, $F=7.10$, $gl=1$) and abundance ($p < 0.001$, $F=42.32$, $gl=1$) of seedlings emerged in the soil, and abundance ($p < 0.001$, $F=13.85$, $gl=1$) of seedlings emerged in the litter, before and after fire, were different. Only one species of litter (*Echinolaena inflexa*) and 11 of soil, emerged before and after fire, while 12 soil species occurred only after fire. The soil is the main component of seed storage and fire reduced the richness and abundance of the seed bank. The studied seed bank presented resilience, with 33% and 57% of the species contained in the soil and litter, respectively, remained present in the area after fire. Thus, the soil seed bank is an important source of natural regeneration in the rupestrian grasslands, mainly in the reestablishment of the community after fire.

T10-P20 - Analysing the evolution of ecological units as an alternative to decide on the restoration of the degraded Atlantic Forests fragments

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For decades, experts have tried to understand how degraded vegetation in fragments recovers after being disrupted by natural or anthropogenic factors. To this day, there is little knowledge about how to assess the resilience of these areas in order to define which ones should be managed for forest restoration and which would recover naturally. From an ecological point of view, conservation of these fragments is extremely important, justifying their insertion into forest restoration projects although academic studies addressing this issue are still scarce. Accordingly, there is a lack of protocols regarding methods and monitoring forest restoration projects in degraded forest fragments. Therefore, it is necessary to develop tools that might assist in the management of these important areas. This study aimed to analyse the dynamics of ecological units within an Atlantic Forest fragment (Mata de Santa Genebra, Campinas, Brazil) regarding their potential for natural recovery. Thus, visual analysis and manual vectorization were performed on aerial photographs available from different disrupted areas over a 22 years period, by comparing changes in ground cover by the forest vegetation. Results showed that 39.4% of the study areas are recovering naturally, and do not need restoratio interventions. On the other hand, 20.5% are still degraded after 22 years, and effective recovery will depend on active restoration interventions. We consider that this method of categorizing areas that are naturally recovering and others that are in a stable degraded state can be used as an important tool to support restoration decisions.

Rehabilitation of severely degraded sites/ reclamation

T15-P01 - The history and characteristics of the environmental rehabilitation of the Córrego do Sítio mine and the importance of the environmental rehabilitation concomitant with mining operation

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The 23-year history of the Córrego do Sítio Mine, owned by Anglogold Ashanti, located in the municipality of Santa Bárbara - MG, show the importance of the rehabilitation of degraded lands by mining concomitant to the operation. Environmental rehabilitation works began in the 1990s, along with mining activities. Even though it is a mandatory activity to do it, before the mine closure, in advance, is the most efficient and environmentally correct way to operate. Currently the mine presents rehabilitated areas in different times and evolution stages, composing a rich mosaic of studies. The landscape included the lands in rehabilitation, the lands in operation and important fragments of native forest preserved (Semideciduous Seasonal Forest). The evolution of the rehabilitation of lands in the past, contributes to reduce the impact of the activity, reduces the visual impact and shows that it is possible to mine in a sustainable way.

T15-P02 - Heavy metal accumulation in *Senecio collinus* (Asteraceae) an endemic species from Peru

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The ability of some native plants to grow in degraded mine soils would indicate their potential use in environmental technologies for revegetation of mine areas or restoration metal contaminated sites. This study evaluates the capacity of *Senecio collinus*, a Peruvian endemic shrub, to accumulate heavy metals (i.e. arsenic, cadmium, copper and lead) from the soil of two localities ubicated on the high Peruvian Andes: Churuca (soils affected by mining) and Ticticocha (soil without contamination). The total metal content of the plants and their associated soils was analyzed by ICP-AES. The results indicated that the accumulation of arsenic and copper in the aerial parts of the Churuca's population was significantly higher than that of the Ticticocha's ($p < 0.05$), however the heavy metal concentration in soils of both localities was not significantly different ($p > 0.05$). On the other hand, the amount of cadmium and lead accumulated in the aerial and roots of *S. collinus* did not show differences between plants of both localities ($p > 0.05$). Furthermore, the analysis of bioaccumulation and translocation factors revealed that this species is a poor accumulator in aerial parts and, therefore, not suitable for phytoextraction. Nevertheless, *S. collinus* acts like an excluder of arsenic and lead because it accumulates those metals efficiently in their roots ($FT < 1$). This suggests that this species has the potential for phytostabilization of sites contaminated by arsenic and lead, but not by cadmium and copper. The present study records for the first time the capacity of *Senecio collinus* as a heavy metal bioaccumulator.

T15-P03 - The research on soil anti-erodibility of Eucalyptus plantation in rare earth tailings area

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Gannan areas of Jiangxi province in southeastern China are important production sites of rare earth minerals in the world. Mining has caused serious soil erosion and many native vegetation cannot survive because of soil acidification, but Eucalyptus can grow well. We assessed soil erodibility in areas covered by different vegetation types: eucalypt plantation one-year-old and two years old and eucalypt sprouting one year after being frozen to death because of low temperature and snow disaster. Mined soils without vegetation cover were used as control. To evaluate anti-erodibility function of eucalypt forest we calculated a soil anti-erodibility index comprised by the proportion of soil particles and organic matter content. The results showed that (1) the

soil anti-erodibility index in the eucalypt plantation two years old >one-year-old eucalyptus> one-year-old eucalypt naturally sprouting>control; (2) Indexes of aggregates, water stable aggregates and clay particles were significantly correlated with soil anti-erodibility index. (3) We analyzed also the correlation between soil properties (physical and chemical), roots and microbial content with soil anti-erodibility index. We found that bulk density, organic matter, bacteria and fungi contents were the key factors influencing the soil anti-erodibility index on rare earth tailings mining area, while soil porosity, aggregate saving chance, pH, soil root characteristics, organic matter, total nitrogen, total phosphorus and total potassium content did not show significant influence on soil erodibility.

T15-P04 - Behaviour of *Erythrina velutina* seedlings in substrate contaminated with diesel oil

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Phytoremediation of soils contaminated by hydrocarbons is a challenging problem in environmental science. This study aimed to evaluate the survival and growth of *Erythrina velutina* seedlings in soil contaminated by diesel oil in a screen house over 8 weeks, at Federal University of RN, Brazil. It involved a control group and treatments corresponding to addition of 5ml, 10ml, 20ml and 40ml of diesel per kilogram of soil. The data obtained were statistically analysed with ANOVA, followed by Kruskal-Wallis and Tukey post-test. The quantity of fuel added to the soil was not sufficient to kill the *E. velutina* seedlings, resulting in a 100% survival rate. A relationship was observed between the amount diesel added to the soil and the height of the seedlings, with higher diesel concentrations producing lower seedlings. We verified also that the 20ml and 40ml treatments resulted in larger seedling diameter than the 5ml and 10ml treatments, this difference indicates net assimilation rates from photosynthesis products, thus it is possible that in soil with a greater exposure to diesel, more carbon assimilation by the root system occurred where carbon availability was higher, which resulted in seedlings with a larger diameter. The robustness index was lower in the presence of high hydrocarbon concentrations, indicating low quality of the seedlings. This studied showed that *Erythrina velutina* presents potential for phytoremediation in programs to recover areas contaminated by oil diesel, but more detailed studies are needed to corroborate this findings.

T15-P05 - Appalachian Regional Reforestation Initiative, and the Forestry Reclamation Approach for successful reforestation of mined lands

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Surface mining of coal has left millions of hectares of drastically disturbed lands in the Appalachian Mountain region of the eastern United States. Many of these lands were originally covered by productive hardwood forests that provided a wide range of ecosystem services and products. The Appalachian Regional Reforestation Initiative (ARRI), a coalition of scientists, citizens, the coal industry, and government, has been involved with reforestation of mined lands in Appalachia since 2004. Through an adaptive learning process, ARRI research scientists studied productive forests on older mine sites and used those conclusions to develop techniques to improve forest vegetation establishment and early stand development for newly reclaimed sites. The Forest Reclamation Approach (FRA) is the outcome of this research. Highly productive forestland can be created on reclaimed mine lands under existing laws and regulations by using the FRA. The basic methods of the FRA may be applicable to forest restoration in other regions and for other disturbance types. Scientists and mine regulators, working collaboratively, have communicated the FRA to the coal industry and to regulatory enforcement personnel. Today, the FRA is applied routinely by many coal mining firms, and thousands of hectares of mined lands have been reclaimed to restore productive mine soils and planted with native forest trees. Now that the FRA has been implemented for more than 10 years, we will discuss longer term implications of these practices for sustained provision of ecosystem services on restored minelands.

T15-P06 - La Chilena Quarry: A successful project of quarry rehabilitation in Costa Rica

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Lafarge-Holcim cement company has three quarries located in Costa Rica. Results of a rehabilitation project at La Chilena Quarry are hereby presented. A first stage of the project was to set a 60 cm soil layer on top of the bare limestone. A complete block design was used where seven treatments were tested: control, compost, compost-mulch, soil substitution, fertilizer, fertilizer-mulch, fertilizer-sand- mulch. A mixture of tree species was used, keeping the same mixture and proportion in all treatments. After a one year period, tree mortality was 15.9% overall. The experiment showed significant differences between treatments, being fertilizer-mulch and fertilizer-sand-mulch the best treatments with an average growth in height of 90.8 ± 30.1 cm and 89.9 ± 29.6 cm respectively. Native species *Ulmus mexicana*, *Citharexylum donnell-smithii* had the best growth response, also *Eucalyptus saligna* and *Acacia mangium*. *E. saligna* and *A. mangium* were used to aid to improve soil physical conditions and provide protection for the native species. Mulch plays an important role in the establishment of trees, mainly in the first six months. In the same period, plant diversity reached 72 species, belonging to 29 families. The families with the highest number of species were Asteraceae and Poaceae. Most of this species are wind dispersed. It is expected, an increase of species which are dispersed by birds; for next stages of rehabilitation, fertilizer application and mulch are recommended as best practices. At the same time, testing new native species is recommended.

T15-P07 - Contributions for restoration in Rio Doce watershed, Brazil: Studies on forest species growth rates in a 6-years permanent plots

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Species selection for restoration programs is a fundamental step for the success of the recovering process. Fast growth is one of the desirable attributes when rapid recovery of degraded areas is the goal, such as the region impacted by the ecological disaster when tons of mud containing tailings destroyed riparian forests in the Doce watershed (Mariana, MG, Brazil). Great efforts will be necessary to restore the degraded areas and the Rio Doce State Park can provide information as a reference ecosystem. Long-term studies on growth rate and biomass increment for forest species could be one of the guides for species selection in restoration projects. In the present study, we assessed, during 6 years, the interannual variation in growth rates of trees in permanent plots of the Atlantic at the Rio Doce State Park. Data were collected in 1-ha-plots, where trees from 207 species (DBH > 10 cm) were tagged and measured annually. A species-ranking list is presented with mean annual diameter increment. For the period of study, the annual average of tree growth was 0.19 cm.year⁻¹, reaching a value of 0.23 cm.year⁻¹ in 2009. In the upper quartile (fast growing species) diameter growth was 163% higher than the average, with broad variation among species. The potential of tree growth and the capacity of carbon fixation of the studied species can be useful to support decisions when selecting species for restoration projects in the study region - the Rio Doce watershed.

T15-P08 - Mimosa scabrella (Fabaceae) enhances the restoration in coal mining areas in the Atlantic Rainforest

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A Pilot Reclamation Project (PRP) was developed in 1982 by the Environmental Protection Agency of the State of Santa Catarina - Brazil, with the objective to evaluating the adaptation of woody species to a land degraded by coal mining. After a full topographic reconstitution of the landscape, addition of nutrient load and sowing of herbaceous species, the area was split into 12 plots in which seedlings of 12 tree species were planted: three native trees (*Bastardiopsis densiflora*, *Mimosa scabrella*, *Schizolobium parahyba*) and nine exotic species (*Eucalyptus saligna*, *E. viminalis*, *E. citriodora*, *Grevillea hilliana*, *Hovenia dulcis*,

Melia azedarach, *Pinus elliottii*, *P. taeda*, *Syzygium cumini*). After 22 years, from the beginning of PRP, the exotic species presented higher percentage of survival than native species; the plots which received either *B. densiflora* and *S. parahyba* or were covered only with herbaceous vegetation associated with solely a few shrubs. Conversely, the plots which received seedlings of *M. scabrella* displayed clear evidence of restoration in progress. The study conducted in plots that have received *M. scabrella* indicate an improvement of nutrient load (N, K, organic matter) in the substrate, a diversified composition of tree coverage (very similar to the nearby remnants of the Atlantic Rainforest) and other life forms, with prominent establishment of native trees with predominance of zoophilous and zoochorous species.

T15-P09 - Environmental restoration of a disposal area of urban solid waste

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The disposal of urban solid waste (USW) in Brazil has a lot of environmental liabilities, like preventing issues on public health and visual pollution, that would compromise the quality of soils, superficial water and groundwater. This way, the National Politics of Solid Wastes, established some goals, knowing that are lot of areas that needs the monitoring over the degraded area. The aim was to evaluate the influence of the natural mitigation process at the vegetation and water in an old disposal area of USW in Passo Fundo-RS. Were conducted studies into the water and the vegetation, and the monitoring of the groundwater were being made in closer streams and into the groundwater table, through the use of piezometers installed over the area. The quantification of the flora are being made for over ten years, identifying the local specimens that shows a natural recovery of the vegetation, with predominance of the specimens *Baccharis* sp., *Ricinus communis* and *Acanthospermum austale*, between the arboreal specimens is highlighted the *Schinus terebinthifolius* and *Solanum mauritianum*. The quality of superficial water and groundwater table, generates concerns, perceiving significant alterations in terms of dissolved ion and high levels of nitrate, as well, BOD and phosphorous. Although the area is into a natural recovery process, the water quality still suffers contamination by the decomposition of waste. But were found herbaceous and arboreal vegetation growing over the mass of this waste, being a indicative that the area can and is being regenerated and reintegrated at the predominant region landscape.

Restoration in parks and protected areas

T17-P01 - Ecological restoration of 20 hectares in the Socha Lagoon Park, Pisba National Natural Park

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PNN Pisba located in the department of Boyacá, in the Eastern mountain range of Colombia, with a maximum height of 3800 m.a.s.l. This park is characterized by its high mountain ecosystems, which have been transformed by the increase of anthropogenic pressures such as mining, extension of the agricultural frontier, and the introduction of exotic species, have been gradually transformed. Thus, the strategies of ecological restoration in 20 hectares of PNN Pisba were formulated, Laguna de Socha, as a contribution to the strategies of conservation of the ecosystems of High mountain that form part of the eastern biological corridor Pisba-Cocuy of the North Andes. The floristic characterization of the vegetal covers found there was realized, and the evaluation of the water resource and of the soil, for the generation of the diagnosis of the zone. The Restoration projects through the active participation of local stakeholders in an environmental education strategy based on exchange of knowledge meetings. We proposed Three restoration scenarios: sectors affected by extensive cattle ranching, water currents and sectors with potential for connectivity with the following treatments: enrichment of degraded areas, protection of stream margins, and induction of scrub-stubble and the implementation of anti-cattle barriers, for controlling this tensioning. Finally, social strategy will be the tool that facilitates the linkage of different actors, recognizing the importance of knowledge of the territory and the dynamics of transformation and long-term sustainability of the restoration process.

T17-P02 - Ecological restoration recovering connectivity after a wild fire in Cerro Aguanoso, Colombia

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The Reserva Forestal Protectora Bosque Oriental de Bogotá was reached by a forest fire in 2016. The Bogotá botanical garden recognized the need to perform restoration interventions and carried out a post-fire ecological restoration in Cerro Aguanoso, a moor ecosystem located 3538 masl, where the vegetation was completely burned. The objective of the intervention was to avoid the external pressures and to reduce competition, thus stimulating natural regeneration of the desired species. Besides, it aimed at maintaining connectivity and decreasing fragmentation inside the reserve. The restoration interventions comprised reactivation of the seed bank, controlling competitive species, transfer of seed bank from undisturbed sites, enrichment with native seeds and rescue and relocation of seedlings. We compared the efficacy of these strategies between east and west mountain faces, that are distinct in environmental attributes. We found differences in the outcomes among the distinct restoration approaches, and also between mountain faces. From the plant species recorded, 70% presented re-sprouting ability, that provided a fast soil recovery. Hence, the high potential for natural and assisted regeneration and also the connectivity with the adjacent high Andean forest patches were determined and evidenced by the presence of native fauna.

T17-P03 - Conceptual model of ecological restoration of a subxerofitic ecosystem in urban area

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The sub-xerophytic areas of the Bogotá Savannah Colombia are part of the Andean Orobioma of the highlands Cundiboyacense, represented in remnants of a type of vegetation that probably had a greater territorial extension in the past and that due to the constant transformation of the landscape given by the continuous Development has reduced isolated fragments immersed in a large anthropic matrix, dominated by agroecosystems, grazing livestock and urban type. As the surface of degraded soils increases, it becomes necessary to adopt restoration techniques, so it is essential to generate research spaces that seek to

expand knowledge about the ecological dynamics of ecosystems that have been altered. The Botanical Garden of Bogotá José Celestino Mutis, line of research in ecological restoration, intervenes the Cantarrana dry dam ecological park, located in the middle basin of the Tunjuelo river, sector where the main relics of the semiarid biome of the Capital District subsist, implementing a model of Ecological restoration of sub-xerophytic ecosystems in urban areas, in order to protect and restore the cover of natural vegetation that still exists in the area. The intervention has resulted in the generation of knowledge about the components, ecological processes, energy flows, disturbance factors and alterations in the landscape that have facilitated the approach and development of research aimed at obtaining the information that demands the restoration of the ecosystem.

T17-P04 - Implementing the ecological restoration to recover the biodiversity in a Brazilian hotspot area – Project Restaurar

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The Brazilian Atlantic Forest is one of the most important hotspots in the world and recognized as the most threatened biome in the planet. Some ecological restoration initiatives to recover this biome are spread in the whole country, but just a few occurs in conservation units. The National Park from Serra do Itajaí (Santa Catarina state, southern Brazil), protects about 57,000 hectares covered by Montana Ombrophilous Dense Forest. In 2013, an ecological restoration project (Restaurar) was initiated, to recover 300 ha from 1.500 ha of degraded pastures inside the park. The first step was a diagnosis to categorize the land uses, geology and type soils predominance. After that, different faunal groups (insects, birds, reptiles, anurans, mammals) were sampled and a phytosociological study in the natural regeneration by plots method (20 plots – 400m² each), conducted to be used as a reference for future comparisons and to characterize the forest structure providing information for plantings. About 2,500 trees were georeferenced as seeds producers to provide appropriate germplasm for seedlings production. Based on the diagnosis 3 nucleation techniques (artificial perches, litter transfer and increasing soil roughness) were choose and implemented alone and in association with planting nursery-raised seedlings, in an area of 51 hectares. Direct seeding was established in 60 hectares and seedlings were planted in 123 ha (adapted Anderson modules (circular) and enrichment), in a density of 1,100 seedlings/ha, selecting 21 indicator species according to the importance value among more than 230 species, as a result from the phytosociological study.

T17-P05 - Ecological restoration of tropical dry forest and cultural and historical recovery: The case of the disappeared town of Armero

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Armero was a thriving cotton growing town in central Colombia. In 1985, an avalanche caused by the eruption of the volcano Nevado del Ruiz, deicing, the flow of mud and the overflow of the river Lagunilla, devastated the town and killed 25,000 people. Three decades later, the government issued Law 1632, whose purpose was to rescue and strengthen the memory and historical-cultural identity of the disappeared city and the projection of its legacy; in the same way, this law promotes tourism and the preservation of the environment. In 2013 a diagnosis was made for the restoration where the presence of limiting factors (presence of *Leucaena leucocephala*) and socio-ecological stressors (grazing, forestry, pilgrimages, among others), obtaining valuable information about a process of spontaneous succession of Tropical Dry Forest (a heavily degraded biome in Colombia). An ecological restoration design was proposed with an urban approach, which also included to rescue the historical and cultural memory through landscaping and a botanical garden that implement an ecological enclosure and connectivity by trails. The current challenge is to achieve implementation of such designs and support the national proposal for a model that, from the socio-ecological systems and the management of socio-environmental conflicts, strengthens the practice of participatory ecological restoration, and increases the likelihood of success of projects and improve governance and sustainability.

T17-P06 - Restoration in the world's first national park: Microtopography as a means for revegetating Yellowstone

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The Greater Yellowstone Ecosystem, located in the northern Rocky Mountains of the western United States, is one of the most intact temperate ecosystems in the world. But Yellowstone is under threat; its massive wildfires, millions of annual tourists, and insect infestations are a cause for concern. However, these threats pale in comparison to the devastation caused by invasive species-- over 15% of documented flora in Yellowstone National Park (YNP) is non-indigenous. *Alyssum desertorum*, an invasive forb that has invaded nearly 300 hectares of YNP has been targeted by the National Park Service with an ambitious and comprehensive revegetation project, launched in 2008. The project has struggled with revegetation success due to variable spring water conditions, which are changing due to a warmer, drier climate. This study looks at microtopography (human-made surface roughness, creating microclimates of small-scale topographic highs and lows) on revegetation sites as a means for improving soil water storage. Microtopography should favor native plants due to increased snow cover, choking out the winter annual *Alyssum desertorum* and holding soil water later into the growing season. Summer censuses of native versus invasive plant densities and frequencies were measured and compared to precipitation, temperature, and soil moisture data in areas receiving topographic treatment and those without. Separate data from a greenhouse study compares the growth of *Alyssum desertorum* to native grasses under drought-induced conditions. This combination of studies has the potential to inform management that microtopography may be a simple and inexpensive fix for revegetation success in semi-arid environments.

Restoration of Andean vegetation/ Páramos

T23-P01 - Macrophytes as bioindicators of water contamination by heavy metals in High Andean lagoons of Central Peru

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In Peru, the main causes of water pollution are caused mainly by industry, mining and agriculture, with aquatic environments being the most affected. The consequences are the loss of plant species and their biodiversity. One of the most vulnerable aquatic ecosystems is the high Andean wetlands due to contamination by heavy metals. The advantages of macrophytes as bioindicators are species sensitive to the presence many contaminants and toxic substances and accumulate contaminants in their organs. The study was made in the lagoons of Yanamate and Quiulacocha (Pasco Region), Ticticocha and Yuracmayo (Region Lima) in central Peru. The highest cadmium accumulation was obtained in *Senecio nutans* roots, and the higher lead accumulation was recorded in *Calamagrostis rigida* roots from the Yanamate lagoon (Pasco Region). Higher copper accumulation was obtained in the roots of *Calamagrostis rigida* from the Quiulacocha lagoon (Pasco Region). *Myriophyllum quitensi* accumulated the lowest cadmium concentration, copper and lead, compared with other two species. *Calamagrostis rigida* and *Senecio nutans* are phytostabilizing species of cadmium, lead and copper and could be used for the remediation of sediments and soils contaminated with heavy metals, and *Myriophyllum quitensi* could be considered as a bioindicator species of water contamination by heavy metals. According to the Peruvian water quality standard (ECA) for lakes and lagoon, the cadmium concentration, copper and lead evaluated in the water of the Yanamate, Quiulacocha and Ticticocha lagoons are above the maximum permissible limits.

T23-P02 - Proposal of a reference ecosystem based on functional traits of the above-ground biomass for the restoration of the high Andean forest

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Forest degradation has structural and functional implications, affecting the ability to provide environmental goods and services, such as carbon stocks. Functional ecology is an important input for the functional restoration of plant communities. It is fundamental to know the functional traits (FT) and structural features that are to be reconstructed, which can be found in a reference ecosystem. The objective of this study was to investigate some FT of trees related to above-ground biomass (AGB), in a reference ecosystem of forest, to know the key species to promote in restoration processes that allow the functional recovery and the capacity to provide ecosystem services in the framework of climate regulation. This study was carried out in a high Andean forest of Colombia, buffer zone of the Chingaza moor, where the less disturbed ecosystem consisted of a large fragment of forest (1363.255ha) over 60 years old. Four traits of tree (DBH > 5cm) were measured, and the community weighted mean (CWM) was calculated. The dominant species provided higher AGB, with high wood densities and height potential (Hmax), and acquisitive and mixed functional strategies, which was corroborated by CWMs. These results suggest that the use of species with particular traits in restoration processes could recover ecosystemic processes related to AGB. Using both acquisitive and mixed species (acquisitive-conservative) would benefit the biomass fixation and storage in these forests, allowing better addressing of restoration processes for this ecosystem.

T23-P03 - Proposal of a reference ecosystem based on functional traits of the above-ground biomass for the restoration of the high Andean forest

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Forest degradation has structural and functional implications, affecting the ability to provide environmental services, such as carbon stocks. Functional ecology allows understand the response and effect of the species to environmental conditions and ecosystem processes, being an important input for the functional restoration of the communities. It is fundamental to know the functional traits (FT) and structural features that are to be reconstructed, which can be found in a reference ecosystem. The objective of this study was to investigate FT of trees related to ecosystem service (ES) carbon fixation-storage in above-ground biomass (AGB), in a reference ecosystem of high Andean forest, to know the key species to promote in restoration processes that allow the functional recovery and the capacity to provide ES in the framework of climate regulation. This study was performed in a large fragment of forest (1363.255ha) over 60 years old, buffer zone of the Chingaza moor, Colombia. Four traits of tree were measured, and the community weighted mean (CWM) was calculated. CWMHmax was the strong driver of AGB, and tree species were classified in acquisitive and conservative for the ES, some exist with strategies of mixed type. These results suggest that in the restoration process, the use of acquisitive species would increase the carbon fixation, favoring the growth of the individuals, and allowing with the time, the greater presence of conservative species, which benefit the storage of biomass and carbon in these forests, improving the management of restoration processes and recovery ES for this ecosystem.

Restoration of Drylands and Mediterranean ecosystems

T20-P01 - Ecological restoration of solar parks – the PIESO project

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The construction of solar parks (photovoltaic power stations) requires shrub removal and soil levelling usually destroying the existing vegetation and degrading soil conditions. Additionally, solar panels change microclimate compared with open habitats. In the framework of an interdisciplinary research and development project (PIESO) we (1) test methods to facilitate the re-establishment of (semi-)natural plant communities that do not compromise energy production and we (2) analyse the influence of solar panels on restoration process.

The experiments were started in 2016 using a solar park in Southern France (Roquefort-des-Corbières) as a model system. The experimental design comprises four restoration treatments, hay transfer from a nearby reference community (dry Mediterranean grassland), sowing a key grass species of this community (*Brachypodium retusum*), adding compost that favour earthworm and a control treatment. All treatments were tested under and outside solar panels in a randomised block design.

Hay transfer increased species richness, and several characteristic species of the reference community got established. Due to the high abundance of ruderal species emerging from the soil seed bank, only small differences in species composition were observed between the treatments. Photosynthetic radiation was 30 times lower under solar panels than outside. Although solar panels prevent the plots underneath from rainfall, the soil humidity was higher suggesting lateral water flow. Nevertheless, total plant cover was higher outside panels in the first season indicating that light availability was limiting plant growth. The second year observations in 2017 will show whether these trends are stable and which restoration treatments are most efficient.

T20-P02 - Herbivore pressure, indirect facilitation and the survival of transplants in a Brazilian degraded semiarid forest

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Survival of transplanted saplings in restoration projects might be controlled by ecological processes such as facilitation and grazing. Facilitation occurs when a plant increases growth and survival of its neighbors. This can happen directly by reducing environmental stress or indirectly by inhibiting herbivore attack. The present study investigates the effects of grazing of domestic livestock and potential nurse tree species (*Zizyphus joazeiro*) on growth and survival of *Caesalpinia pyramidalis* and *Zizyphus joazeiro* saplings transplanted to a degraded area. We performed an experiment where Nurse treatments (presence or absence of *Zizyphus joazeiro* trees), Grazing treatments (presence or absence of fences), Target treatments (*Poincianella pyramidalis* and *Zizyphus joazeiro* seedlings and juveniles) were all randomized in a factorial block design with a total of seven experimental blocks. Grazing increased the mortality for both target species and decreased the height of the herbaceous cover. The tree *Z. joazeiro* did not increase growth of target species even though it improved microclimate. Alternative models including variation in herbaceous height as an explanatory variable indicated that taller herbaceous cover increases saplings survival probability for *C. pyramidalis*. These analyzes indicate that the presence of indirect facilitation may be more prevalent than previously thought in degraded semi-arid environments that suffer domestic livestock grazing. Sapling mortality in semiarid environments might be directly related to grazing and trampling, as well as by modification in soil structure and herbaceous vegetation caused by livestock.

T20-P03 - Strategies for water management for seedlings of Caatinga native species under field conditions

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Understanding how native plant species perform over their juvenile stage in the restoration of degraded semiarid regions is a big scientific challenge.

In order to evaluate the efficiency of water management strategies used by Caatinga young plants in degraded environments, this study analysed photosynthetic rates, gas exchange and fluorescence of chlorophyll a in seedlings of *Crataeva tapia*, *Erythrina mulungu*, *Handroanthus impetiginosus*, *Tabebuia aurea* and *Ziziphus joazeiro* under field conditions. The study was conducted in an experimental area of the Universidade Federal de Alagoas – Arapiraca campus. The experimental design used randomized blocks with factorial arrangement of 5x5 (species x treatments). The treatments used were control, waterbox, cattle manure, hydrogel, and cattle manure with hydrogel. Waterbox and hydrogel used during the planting period, in association or not with cattle manure, yielded bigger photosynthetic rates, bigger gas exchange, and bigger maximum quantum efficiency of the photosystem II (PSII) in *T. aurea*, *H. impetiginosus*, *C. tapia* and *E. mulungu*. The species *Z. joazeiro* presented adaptive characteristics to the most severe environmental conditions, including water management efficiency and absence of damage to the photosynthetic apparatus through the high rate of F_v/F_m . Therefore, the use of hydrogel with cattle manure is indicated for *T. aurea*. However, for *H. impetiginosus*, *C. tapia* and *E. mulungu* it is recommended the use of hydrogel at the planting period as a water management strategy for the survival and initial growth of the seedlings of these species.

T20-P04 - Biological soil crusts prevent biological invasion of exotic plants in arid desert regions of China

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BSCs are widely distributed in arid and semi-arid landscapes, which account for 33–40% of the Earth's terrestrial surface. BSCs limited the germination, establishment and survival of exotic plants via changing the physical, chemical and biological properties of sand topsoil, as well as altering distribution of seed rain and seed bank in soil under wind erosion condition. We though field investigation and control test to simulate and verify the influence of BSC on plants establishment and seedling survival. The results of study showed that these effects represented reducing the amount of soil seed bank and chances to germinate and establish of exotic plants due to reducing stay for a time of seed induced by surface cover and water competitions of crustal communities. The later successional stage of BSCs dominated by mosses and lichen has a higher capacity to impede seed entrapment in topsoils rather than early stage of BSCs dominated by cyanobacteria result in the difficulty to enter topsoil. There were significant increase in germination and establishment of exotic plants in case of BSCs have been removed from surface cover or destroyed, in addition, the presence of BSCs in desert ecosystems benefit survival of grass rather than shrub. The results of this study may be affected by biological traits of measured plant seeds, such as size, shape and dispersal, dormancy and seed vitality etc in arid desert regions.

T20-P05 - Using nurse plant species-specific effects to restore semiarid tropical forests

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The Brazilian Caatinga forest is one of the most diverse semiarid forests in the world. More than 50% of its territory is degraded and 13% is facing desertification making restoration an urgent matter. Nurse plants have been presented as a solution to improve semiarid restoration due to their potential for positive interactions. However, the majority of plant interactions outcomes in the world are species-specific, with positive or negative outcomes depending on species identity. We test the complexity of species-specific interactions in Caatinga through different successional stages to propose the best plant species combinations to optimize Caatinga restoration. We conducted a factorial field experiment using 20 potential tree nurse species and three target

species. Each pair-wise combination was replicated five times in 100 blocks. Target plants were transplanted below and far from the nurse plant canopy. We monitored target's performance in survival and growth for 275 days. The outcome of species-specific interactions was calculated with a GLMM. Plant interactions are very species-specific for growth but not for survival. The same nurse species can exert positive effects on one target species and negative effects on others. The positive average effect of one nurse species does not necessarily mean a positive effect in all target species. All nurse successional stages have potential to facilitate and inhibit target species. Thus, we suggest a table of species combinations to optimize restoration based on species-specific matches. We suggest that future studies should consider plant interactions in a species-specific scale to improve restoration programs.

T20-P06 - Learning from field experiments to design new strategies for drylands soil restoration focused on biocrusts-plants combination

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Arid and semi-arid ecosystems are characterized by a sparse vegetation cover and interplant areas are usually colonised by biocrusts which play a major role in water and nutrient fluxes affecting the establishment of vascular plants and in maintaining their productivity. However, very few studies have indeed analysed how water and nutrient fluxes from biocrusts affect established vegetation. Our objective is to demonstrate that run-on water and nutrients provided by biocrusts are crucial resources for vegetation survival. We performed an experiment to analyse the response of *Stipa tenacissima* to the exclusion of the runoff provided by biocrusts at Almería (SE-Spain), setting 6 experimental plots, including each one a plant of *Stipa*. On 3 of them, run-on from biocrust-covered upstream areas was excluded whereas the other 3 were maintained as control open plots. We monitored vegetation phenology and productivity in different periods during the last 3 years, in which net C uptake of the plant leaves and their spectral response were measured and total above ground biomass and photosynthetically active biomass per plant were estimated. Plants from open plots showed more photosynthetically active biomass and net C uptake rates than plants under run-on exclusion. Differences between treatments increased over time and were especially important after rainfalls. We concluded that water and nutrients provided by biocrusts had an important effect on vegetation performance. Thus, a restoration strategy combining plants and soil inoculation with biocrusts in open areas will provide runoff water and nutrients to vegetated patches increasing plant survival and productivity.

T20-P07 - Nucleation from artificial lakes as revegetation strategy of degraded areas in Brazilian semiarid

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Facing the many challenges on the recovery of degraded areas resulting from recent infrastructure projects in the Brazilian semi-arid, the scarcity and irregularity of rainfalls are highlighted. This fact is making traditional models to be ineffective, whether by the high cost of management or by the high seedlings mortality. An alternative may be nucleation from rainwater concentration in small artificial lakes. This study assessed the effect of the distance from water in the survival and growth of 14 Caatinga native species. Considering a 5 meters strip from the water, 10 lines perpendicular to the margin were installed for each species, where five seedlings were planted at every 1 meter. After two years without maintenance we observed that the intraspecific survival was indifferent to water distance. *Jatropha mollissima* (1), *Croton blanchetianus* (2), *Mimosa tenuiflora* (3), *Pseudobombax marginatum* (4), *Poincianella pyramidalis* (5) and *Ziziphus joazeiro* (6) presented higher survival, followed by *Libidibia ferrea* (7). Growth rates did not differ in relation to lake distance for the first five species of higher survival. The greatest height growth rates were observed in species 3, 7, 1 and 2. The highest increments in stem diameter were observed in species 1, 2 and 3. Our results indicate that the six species with higher survival are more adapted to the environmental stress of the semiarid, and may be considered viable species to the restoration of Caatinga's vegetation cover. The proposed model was efficient, presenting low cost and ensuring the survival and development of different species.

T20-P08 - Distribution of *Panicum turgidum* plant community in Kuwait and restoration measures

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Panicum turgidum Forssk is a perennial grass widely distributed in most deserts of the Middle East. It is a remarkable drought-resistant species and the established plants may survive for several years without rain. *Panicum turgidum* is economically important because of its use as a sand binder, as a forage plant in arid areas and as a source of grains. In Kuwait, the plant community has been under severe pressure from many factors, such as overgrazing and seasonal camping as well as military activities during war. The vegetation map of Kuwait showed alternation in plant (*Panicetum*) community's distribution from 1974 to 2005. This alteration was due to anthropogenic and climatic factors; such as grazing, camping and droughts. The distribution of the plant community is currently limited to a small area in the southeastern Kuwait with a total area of 11,391 ha and a total percentage distribution of 0.7% of the total vegetation map units. This community is located in the Shuaiba Industrial Area owned by Kuwait National Petroleum Company (KNPC), which expanded its industrial development including the area covered by this plant community. Some efforts are being exerted to establish seedlings of *Panicum turgidum* to restore the damaged areas and to use the plant as a source of protein for livestock production as well as to establish in situ protection of the community. It is necessary to carry out research for large-scale reproduction of seedlings and to assess the current distribution of the plant community for recommending a conservation plan.

Restoration of Temperate and Boreal Forests

T21-P01 - Forest naturalness restoration: an example of Pautsjärve nature reserve, Karula National Park, Estonia

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In Europe, the coherence of natural forests continues to decline strongly due to large-scale and intensive forest management activities. To reduce this negative trend, particular elements of natural forests should be introduced into managed forests to enhance ecological functionality of managed forests and promote the structure of natural forests in the forested landscape. In 2014 and 2015, the nature reserve of Pautsjärve in Karula National Park was studied for identifying the structural elements and biological legacies of natural forests. The study showed that important elements of the diverse forest reserve were large trees and trees with different diameter classes (more trees on the understorey), a moderate amount of deadwood, coarse woody debris and natural regeneration of different tree species. To speed up the introduction of the natural forest elements to managed forests in Karula National Park, 20 test areas to one forest district in the national park were created in 2000, using the restoration methods, such as gap cutting, gap cutting with deadwood retained, gap cutting with branch burning and gap cutting with area burning. By monitoring the test areas 15 years after the restoration treatments, we found that implemented forest naturalness techniques have significantly contributed to the change of a managed forest into more natural and diverse conditions and biodiversity similar to the forests in the nature reserve. This study established that restoring forest naturalness by leaving natural forest elements in managed forests should increase the biodiversity of managed forests and reduce the fragmentation of nature protection areas.

T21-P02 - Rare and threatened species success development on southern Brazil degraded remnants: A biodiversity improvement case in Araucaria Forest

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The low presence of rare or endangered species seedlings in restoration or natural areas enrichment still presents a great gap in terms of achieving the deepest objectives of restoration process, either by their production process or performance in the field. In order to increase the use of these species in the Araucaria Forest region, experimental plantations were carried out for forest enrichment purposes in four private properties and a National Forest, all located in Campo Largo municipality, Southern Brazil (Cfb climate by Koeppen). We planted 560 seedlings (2.0x2.0 m) from 13 native species considered naturally rare or under some kind of threat inside low density forest fragments. Measurement of height, diameter at ground and survival rate were done during planting, at years 01 and 02. Total survival average through species was 95.6%. *Myrcianthes gigantea* had lowest number of living seedlings after 2 years (87.5%) while *Eugenia pyriformis* was the most successful (99.5%). Survival rate from all sites were 95.1%, and the lowest value was found in the Açungui National Forest (92.5%). Average height was 30.54 (± 13.50) cm at time zero, 47.25 (± 23.15) cm in year 01 and 61.78 (± 36.19) cm in year 02. Diameter at ground increased from 5.54 (± 2.99) cm at planting to 8.02 (± 5.98) cm in year 02. *Acca sellowiana* had the largest diameter improvement (14.81 cm), while other species ranged from 0.05 to 4.05 cm. Use of rare and threatened species to enrich degraded forests can be highly successful to improve richness and diversity of them.

T21-P03 - Considering soil/ water/plant interactions to settle functional groups in riparian Araucaria Forest restoration projects at South Brazil.

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Restoration projects in fragmented and degraded riparian landscapes should consider soil/ water/plant interactions to achieve their goals. Knowing hydric regime should be helpful to decide which functional group would be more suitable – if hydrophilic (water level ever above 50cm), hygrophilous (water level between 50 and 100cm) or mesophilic (water level ever lower than 100cm). We have gathered data from six patches of riparian Araucaria Forest (Mata Atlântica Biome) at Paraná State in order to propose species lists in two functional groups according to their position in the landscape, considering soil type and water level. We analyzed soils in perpendicular topographic sequences to Pitangui and Jotuva rivers. The local water level was measured monthly through 12 one meter long hydric wells. Phytosociological analysis evolved 76 5X10m plots and resulted in a mesophilic 58-species list and a hygrophilous 64-species list. Non-hydromorphic Haplic Inceptisols or Litholic Leptosols support mesophilic forests whereas semi-hydromorphic Melanic Gleysols or Fluvic Leptosols support hygrophilous one. *Araucaria angustifolia* (Bertol.) Kuntze, *Nectandra grandiflora* Ness, *Clethra scabra* Pers., and *Myrceugenia ovata* (Hook. & Arn.) O.Berg. are typical for the mesophilic group; *Sebastiania BRAZILIENSIS* Spreng., and *Trichilia elegans* A.Juss. are typical for the hygrophilic group. The taxa *Allophylus edulis* (A.St.-Hil., A.Juss. & Cambess.) Radlk, *Matayba elaeagnoides* Radlk, *Myrciaria tenella* (DC.) O.Berg, and *Sebastiania commersoniana* (Baill.) L.B.Sm. & Downs are abundant in both functional groups, so they could be used for major restoration projects in spite of water ground level and soil type.

Restoration of Tropical Forests

T22-P01 - Restoration of bauxite mined areas by the nucleation technique, Amazon Rainforest, Brazil

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When a bauxite mine located in Pará, Brazil, opened its strips (2012), we adopted a new method of restoration of mined areas that consisted on the displacement of the topsoil/tree branches mixture, forming a rough surface covered with mounds that creates micro basins for rainwater percolation and acceleration of neopedogenesis. The project required the annual assessment of environmental indicators: presence of erosive processes, soil cover rate, vascular plants diversity and the density of regenerating individuals. The data obtained in the areas restored in the period of 2012-2014 showed, respectively for each year: soil cover of 86, 46 and 56%; species diversity of 75, 66 and 50; number of individuals/ha of 4400, 3680 and 11380. In addition, we registered the natural regeneration of 91 species being: 44 trees, 27 lianas, 11 shrubs and 9 herbs. No erosive processes were found. The cover was characterized, mainly, by the predominance of *Ipomoea* spp., *Solanum* spp., *Trema micrantha* and *Cecropia* spp. followed by a greater diversity of species. Soil coverage, diversity and species density data suggest the introduction of seedlings in the mined areas after the third year, when the environment will be more conducive to the development of species that require more specific soil and light conditions. The method begins with cover species through natural regeneration, adding diversity later on the succession. The layout of mounds has brought operational improvements making the method more environmentally efficient and less costly. This method has been a model for other Brazilian bauxite miners.

T22-P02 - Efficacy of soil preparation, herbicides and green manure to control the invasive grass *Urochloa decumbens* in tropical forest restoration

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The use of green manure has been proposed as a strategy to control competitive species and to improve soil conditions in areas undergoing forest restoration, but few studies have investigated the efficacy of this technique. We conducted a split-plot experiment to test the efficacy of green manure (*Canavalia ensiformis* and *Cajanus cajan*) combined with different soil preparation and maintenance techniques (herbicides or mowing) to control *U. decumbens* after planting nursery raised tree seedlings (Itu, SP, Brazil). The primary treatments were: no soil plowing (R) and disking (G). The secondary treatments were: herbicide before and after planting seedlings (H); herbicide before + seeding *C. ensiformis* + mowing (FP+H); herbicide before + seeding *C. cajan* + mowing (H+FG); seeding *C. ensiformis* + mowing (FP), seeding *C. cajan* + mowing (FG); and just mowing (s/Hs/AV). We assessed ground cover and height of the exotic grass and seedlings growth. In the period between planting and the first maintenance, the interactions R (H + FP) and R (H + FG) were effective in controlling the exotic grass. After that period, however, only treatment (H) reduced the ground cover and height of the invasive grass. Nine months after planting, only treatment (H) resulted in seedlings with larger canopy area. Plowing the soil and applying herbicides were, therefore, effective in controlling the invasive grass in the short term. After nine months, however, only re-application of herbicides provided grass control and promoted seedlings growth. Green manure did not help to control the exotic grass nor enhanced seedlings growth in this experiment.

T22-P03 - Functional diversity in reforested areas may reflect variation found naturally in tropical forests

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At the margins of many Brazilian hydropower reservoirs, reforested patches differing simultaneously in size, age and in the techniques used over the last four decades coexist. The absence of planting and management standards make it difficult to evaluate the effect of time and size, f. ex., on the success of reforestations, but on the other hand, it adds to the landscape spatial and temporal diversity of ecological processes. We estimated the contribution of reforested patches around the Volta Grande hydroelectric dam (Minas Gerais), for carbon stocks and nutrient cycling and aimed to verify correlations with phytosociological parameters, size and age of the plots, regardless of the initial methods of planting. The carbon stock in the tree-aboveground biomass varied from 50 to 109 tC.ha⁻¹ and was not related to plot size or age. It seems to be more dependent on the species composition and plant density. Litter production was positively related to tree density, which was highest in the older (>30yr) and larger (>100m) patches. However, these areas also presented higher Ca, K, Mg and N contents in leaf-litter and faster decomposition rates, resulting in lower C stocks in litter-layer (3.4 tC.ha⁻¹) than that estimated for younger (<10yr) and narrower (<30m) areas (6.6 tC.ha⁻¹). Older stands stored more carbon in the soil, probably due to higher litter production and decomposition. The values are in line with variation found in response to the gradient of plant density naturally found in some tropical biomes. Funding: Fapemig, CNPq.

T22-P04 - Evaluation of restoration processes with tree seedlings planted in a permanent protection of Anhumas Stream, Bonito, Mato Grosso do Sul

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Agriculture can impact the environment when developed without adequate management. In Brazil, this activity is one of the major causes for the suppression of native vegetation, causing erosion, silting and loss of biodiversity. Due to these impacts, many rural properties were demanded to restore, especially in areas adjacent to water courses. These can be developed with nucleation techniques, such as the diversity islands. The objective of this study was to evaluate a restoration project based on diversity islands in a private farm area along the margins of Anhumas Stream, Bonito, Mato Grosso do Sul, Center of Brazil. Total restored area covered 5,6 hectares, 243 islands planted 10 m apart, totaling 1360 seedlings. All nuclei were composed by 13 seedlings of different species, apart 1 m from each other, and pioneers were planted outside and climax inside the nuclei. Weeding was carried out twice in one year. After this period, plant species were identified, measured (height and diameter at the stem base), and survival estimated. The survival percentage (70%) was higher than those usually found in the region. Average height (2.1 m) and stem diameter (33.8 mm) in pioneer species were significantly higher than in secondary species (0.8 m height and 22.3 mm diameter). Therefore, pioneers species were the most successful group. The differential of this planting was the constant weeding of exotic grasses, in addition to irrigation when there were long periods of drought. Results demonstrated that management interventions are essential for restoration with the nucleation technique used.

T22-P05 - In 60 days: Suppression of aggressive grass and creation of safe-sites for seedlings using transient shrubs cover for the restoration of tropical forests

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To speed up tropical forest restoration, we propose a new strategy consisting of, firstly, creating a temporary shrub canopy and, then, a tree canopy. The temporary shrub canopy would be formed in 8-10 weeks and would cover, shade and eliminate the exotic aggressive grasses, forming at the same time safe-sites to favor native forest species regeneration. After 2-3 years the shrub canopy would be overtopped, shaded and eliminated by a continuous tree canopy, dominated by pioneers. This strategy

can drastically reduce restoration costs, because normally tree canopy closure and grass elimination demand two years of intensive management, while the shrub canopy can eliminate grasses in only two months. Moreover, at the same time, 50% of the bare soil (areas in between tree lines in plantations) or 100% of bare soil (in pastures) could be converted in safe-sites for tree regeneration. We are testing this strategy by comparing traditional grass control and the control by transient canopy of two different fast-growing shrub species, *Ricinus communis* (Euphorbiaceae, exotic) and *Vernonia polyanthes* (Asteraceae, native). The experiment was implemented in Sertãozinho, SP, Brazil, as part of a project to restore the tropical forest from pastures. We used four blocks and three treatments; traditional grass control, and *Ricinus* and *Vernonia* direct seeding between tree lines. The first results show that *Ricinus* transient canopy was formed in only 60 days and was able to eliminate the exotic aggressive grass (*Brachiaria brizantha* cv. Marandu). Now, we are monitoring natural regeneration under this canopy.

T22-P06 - Composition and structure of liana assemblages on different semideciduous tropical forest restoration systems

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Lianas are major components of tropical forests, contributing significantly to their structure, composition and interspecific interactions, as well as to the ecosystem functioning and ecological processes. Regardless of their importance, the role of lianas in tropical forest restoration has been neglected. We studied the composition and structure of liana communities in different restoration systems of the seasonal tropical forest (Atlantic forest). Our hypothesis is that the more complex the restored canopy is (species richness, stratification and tree architectural diversity) more diverse and less abundant will be the associated liana community. We sampled four contrasting seasonal tropical forest restoration systems, established 19 years ago in Botucatu, São Paulo-BR: direct seeding of fast-growing species (DS); agroforestry system with 20 tree species (AFS); mixed commercial plantation with 25 timber and firewood species (COM); and high-diversity plantation of 40 different functional groups species (HD). All liana stems (>2cm of DBH, diameter at breast height) were counted, identified and measured (DBH) in two 10 x 10 subplots in each restoration plot. We also evaluated vegetation stratification and canopy coverage. We found 1,143 individuals and 76 morph species. Our preliminary results showed that restoration systems differ in liana abundance, with higher liana densities in the DS and the COM systems. No significant differences in liana species diversity were found between systems (Fisher's alpha and Pielou). Our data suggest an effect of planted trees density and canopy openings in liana density, variables more related, respectively, to the commercial mixed plantation (COM) and direct seeding (DS) systems.

T22-P07 - Direct seeding of *Eugenia uniflora* for riparian forest restoration in the Atlantic Forest Biome, south Brazil

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Direct seeding can be a potential alternative for ecological restoration with low execution cost, but it has been poorly studied, mainly, in subtropical conditions. The aimed of the study was to evaluate the emergence, establishment and growth of *Eugenia uniflora* L. for riparian forest restoration in an Deciduous Seasonal Forest, Atlantic Forest biome, Rio Grande do Sul State, Brazil. Seeds of *E. uniflora* were sown in lines with 2 m between rows and 1 m of line spacing. Emergence, survival and initial height development were evaluated every 30 days for 12 months. The germination rate and the relative growth rate were calculated. After a year *E. uniflora* presented 68% of germination, 83% of survival, average height of 6.1 cm and relative growth rate of 36.84%. The high values of the germination rate and relative growth can be related to the ecological characteristics of the species, characterized as initial colonizer, besides to seed size (mean mass of 353.5 mg). We concluded that *E. uniflora* could be a potential species for direct seeding in ecological restoration projects; however, other studies are necessary to validate procedures and recommendation to other species from region.

T22-P08 - Optimizing stock production of native epiphytic plants to diversify Restoration of Seasonally Dry Semideciduous Tropical Forest (Atlantic Forest) in Brazil

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In Brazil, forest restoration of native tree species has been the main form of ecological reforestation. The need for inclusion of other life forms has been discussed, considering the need to represent diverse functional groups in restored forests. Therefore, we evaluated the growth and development of 4 epiphyte species typical of Seasonally Dry Semideciduous Forest in a greenhouse under two levels of light, humidity, substrate and availability of pre-established and controlled nutrients, respectively. They are: *Bilbergia zebrina* (Bromeliaceae), *Aechmea bromeliifolia* (Bromeliaceae), *Phylodendron bipinnatifidum* (Araceae), *Epiphyllum phyllanthus* (Cactaceae). The aim was to optimize planting stock production for diversification of restoration projects and understand the ecophysiological relationships of these species with the climatic changes of the environment according to the different growth curves. Plant height, number of leaves and length of the largest leaf were measured four times at three-month intervals over a year. All species presented interactions among light, water and nutrients for all parameters analyzed and for those parameters in a shaded environment, the interaction between the presence of substrate and nutritional contribution was essential for the highest levels of growth, while in the condition of high luminous intensity, water was the limiting factor. Determining the optimum conditions for growth and development, in this way, will not only enable efficient production of planting stock to diversify Forest Restoration Projects, it will also enable better management of the plants post-reintroduction. Ultimately, this work will enable increased representation of epiphytes in forest restoration projects throughout the Atlantic Forest biome.

T22-P09 - Floristic inventories and their importance for ecological restoration strategies in the dry forests of Ecuador

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The phytosociological studies are a key tool for modeling ecological restoration processes and conservation strategies, whose objectives are to obtain lists of regional species for enrichment of degraded forest remnants; to identify shrub and tree species, allowing the collection of genetically based seeds; and to implement ecological routes in different areas of the region, that are used as tools of valorization and conservation of the biodiversity of these forests. This study aimed to know the floristic composition and structure of native species of the Andean dry forest of the Pisaca Natural Reserve for conservation of potential matrices for seed collection. From, three L-shaped conglomerates located in different altitudinal gradients (1800, 2000, 2300 m), where all the individuals ≥ 5 cm d.b.h. (diameter at breast height) were located, measured and identified. Then, we calculated structural and phytosociological parameters. We identified a total of 2012 individuals, belonging to 40 morphotypes distributed in 23 families, 35 genera, 37 species, 2 morphospecies and 1 morphotype. The families with the greatest diversity were Asteraceae, followed by Fabaceae and Myrtaceae. The species with high importance value index were *Myrcianthes* sp., *Lafoensia acuminata*, *Xylosma* sp., and *Mauria heterophylla*, these species by their successional classification are part of the models of restoration of degraded areas at similar altitudes. The results obtained in this study are useful for the conservation and selection of potential matrices for ecological restoration of areas of the Southern region of Ecuador.

T22-P10 - *Euterpe edulis* (Arecaceae) and the enrichment of restored areas in southeast Brazil: the role of environmental filters

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The Atlantic Forest in southeast Brazil has undergone a continuous deforestation process. Restoring or enriching degraded areas can effectively mitigate this situation. Even though the palm *Euterpe edulis* has a high ecological value as an important food source to many frugivorous animals, its biology in restored areas is still poorly known. We aimed to evaluate the effect of environmental filters on the survival of *Euterpe edulis* in an Atlantic forest restored area in southeast Brazil. We assessed the potential of germination, seed predation, and the effect of litterfall on germination through the placement of individual seeds, half protected by cages to avoid litterfall and vertebrate predators. We also planted juveniles in three areas with different canopy covers to evaluate the effect of light on their development. Finally, we assessed the effect of herbivory on both germinated seedlings and juveniles. We found that 71% of seeds germinated, but germination was higher in uncaged seeds, as litterfall can promote moisture maintenance. Only 10% of the uncaged seeds were predated, suggesting seed predation as a weak filter to germination. Light directly affected the development of juveniles, with individuals planted in an intermediate canopy cover growing taller than those in brighter or shady areas. Herbivory rarely affected juvenile survivorship, but played a role in seedling mortality. Since these environmental filters least affected the survival of this species in the study area, we recommend the enrichment of restored areas with this palm, whose attractiveness to frugivores can contribute to the recovery of lost mutualistic interactions.

T22-P11 - Seed rain and seed bank in restoration plantation of a semi-deciduous seasonal forest: Effect of vegetation structure and surrounding landscape

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Seed availability is an important factor for the regeneration and persistence of the plant community in a given habitat. During restoration, seed banks and seeds rain contribute either for the persistence of the introduced species and the arrival and establishment of new colonists. We studied the composition and dynamics of the seed rain and soil seed bank in different restoration systems on the tropical seasonal forest, to evaluate the interaction between internal (vegetation structure) and external (landscape) factors in the community assembling. We evaluated two experimental sites at Botucatu-SP, Brazil, each one having five restoration systems established in 1997-1998 in a random block design with three replicates. The seed deposition density was higher in most restoration plantations of both sites, in comparison to a reference forest fragment, and seed rain was strongly dominated by anemochoric seeds, and lianas. We also found a predominance of allochthonous dispersal in two of the restoration plantations in both sites, indicating an important contribution of neighboring landscape particularly when local species richness is lower. The soil seed bank was composed mainly by herbaceous species in all restoration systems in both sites. Regardless of the characteristics of the studied sites, seed rain is a result of interaction between the surrounding landscape and the restoration systems, resulting in high seed inputs to those plantings. Nevertheless, the seed bank takes a longer time to recover, and rely strongly on the tree species that are beginning to colonize the community after 18 years of planting.

T22-P12 - Canopy tree and seedling species identity can determine the species reintroduction success

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Improvement of species reintroduction as a restoration technique are needed. The aim of this study was to verify the effects of canopy and seedling species on the mortality of seedlings. We addressed monospecific stands of 9 native species: *Balfourodendron riedelianum*, *Cariniana legalis*, *Cordia trichotoma*, *Enterolobium contortisiliquum*, *Gallesia integrifolia*, *Handroanthus heptaphyllus*, *H. vellosi*, *Myracrodruon urundeuva*, *Peltophorum dubium*. The stands are more than 24-year-old, in São Paulo state,

SE Brazil. We set up 27 plots, 3 under the canopy of each species. In each plot, we planted 45 seedlings of the same 9 species established in monospecific stands. We assessed seedling mortality (SM) differences within canopy and seedling species using ANOVA, followed by pairwise comparison test (Bonferroni). We used Spearman correlation to test the relationships between SM and pathogen attack. Canopy and seedling species explained the SM, however interaction between them was not significant. The SM within canopy species was higher for *E. contortisiliquum* (16%) and *C. legalis* (15%) and lower than 10 % for the others. The SM within seedling species was higher for *M. urundeuva* (37%), *C. legalis* (11%) and *P. dubium* (10%) and lower than 10% for the others. We did not find SM for *C. trichotoma* and *B. riedelianum*. Pathogen attack was correlated to SM. Our results suggest that SM is affected by both canopy species, by altering the environment, and the characteristics of each seedling species (e.g. pathogen resistance). Our results highlighted the importance of the canopy tree and seedling species identity to achieve species reintroduction success.

T22-P13 - Potential species for ecological restoration in the Atlantic Rainforest, how to select?

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Seedlings planting is restoration technique widely used in Brazil. However, for the use of this practice its necessary a previous knowledge from autochthonous species, ecological groups, and species densities in the area to be restored. This information is mostly absent in most of the degraded environments in Brazil. In this way, this study has the objective to evaluate the phytosociological parameters in two different sucessional stages in a Subtropical Atlantic Rainforest fragment (National Park of Serra do Itajaí, Santa Catarina state), to determine which species are representative each natural regeneration stage, and also their respective densities. The surveys were conducted by the plots method in two different sucessional phases with 40 plots (10 X 20 m each), 20 plots in the initial regeneration stage and 20 plots in the intermediate stage. The PCA analyses show the differences among the plots segregating the two stages. The species grouped as pioneer were distinguished in both stages, especially *Vernonanthura discolor* (Asteraceae), *Piptocarpha regnellii* (Asteraceae). To understand the species composition and their densities structural parameters were evaluated. The results suggests that enrichment planting for this two species should be about 193 ind/ha and 143 ind/ha, respectively. We hope that this methodology could help future restoration projects to decide how to plant and enrich in the Atlantic Rainforest.

T22-P14 - Organic mineral fertilizers as potentiators of the development of Atlantic Forest species

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Forest restoration process benefit from plants rapid development and soil shading. In the scope of an R&D Project lead by AES-Tietê and IPEF, an experiment was carried out in Piracicaba, São Paulo State, Brazil, in order to evaluate two different types and quantities of fertilizers in tree development. The experiment was based on a randomized complete block design, with 3 replications and 10 treatments: [1] Control; [2] MF (Mineral fertilizer in recommended dose); [3] MF + CAL V=50% (liming at 50% base saturation); [4] MF + CAL V=50% + MIC (micronutrients); [5] 2 x FM + CAL V=50% + MIC; [6] 2 x FM + CAL V=80%+ MIC; [7] OMF (Organic mineral fertilizer in recommended dose); [8] OMF + CAL V=50% + MIC; [9] 2 x OMF + CAL V=50%; [10] 2x FOM + CAL V=80%. Each plot had 100 tree plants and 20 species, 50% pioneer and 50% non-pioneer. At 12th month of planting, base stem diameter (BSD), height (H) and crown diameter (CD) were measured and then compared by one-way ANOVA, followed by multiple comparisons Fisher's LSD test, both at ($\alpha=0.05$). Treatments [9] and [10] (duplicated dose of organic mineral fertilizer) obtained higher averages in (BSD), (H) and (CD) for both pioneer and non-pioneer species, although they are significantly equal ($p < 0.05$) to treatments [5] and [6]. Results demonstrated that fertilizer type did not alter species development and the quantity can be used in favor of more rapid crown closure in forest restoration areas.

T22-P15 - Phytosociology of a riparian tropical forest undergoing restoration, Divinópolis, Minas Gerais state, Brazil

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Assessing the structure and composition of restored ecosystems is a challenge for evaluating restoration success. We assessed the development of a riparian forest undergoing restoration by means of phytosociological methods. We sampled the arboreal community at five years after planting, in a restored area of 7,020 square meters along the Itapecerica river (Divinópolis, MG, Brazil). Trees were identified in the field, and circumferences at breast height were measured. From these data we obtained for each species phytosociological parameters such as absolute and relative density, frequency, dominance, and simplified importance value. We recorded 70 arboreal and shrubby species, which belong to 56 genus (27 families). The community resulting from restoration was dominated by fast growing trees, that presented the highest importance values, that are: *Inga uruguensis*, *Triplaris americana*, *Citharexylum myrianthum*, *Inga laurina*, *Handroanthus roseo-alba*, *Syzygium cumini*, *Schizolobium parahyba*, *Cariniana estrellensis*, and *Enterolobium contortisiliquum*. These species, in the first years after restoration, have high dominance (large diameters and basal area) and *Inga uruguensis* species stood out due to the higher density among the planted trees. Some of the dominant species are not native in the region (*Triplaris americana*, *Syzygium cumini*, *Schizolobium parahyba*) and that means the composition of the restored forest is different from the native forests in the region and the performance of these species in the community long term must be monitored.

T22-P16 - Framework species selection for direct seeding in areas of transition of seasonal forest and savanna in the Xingu River basin, Brazil

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The success of the establishment of tree species in the restoration of Seasonal Forest and Savanna transition areas may be related to species fitness. We studied a restoration area using direct seeding in a transition zone from seasonal forest to savanna based on the framework species approach. We evaluated an 8-years 0.98 ha area planted in 2008 sowed manually with 31 species (A1) and another one 6-year 3.4 ha area planted in 2010 by mechanized seeding with 62 species (A2). All seeds were mixed using the “muvuca” method by Xingu Seed Network. We assessed the areas in 2014 and 2016 in 35 (A1) and 45 (A2) circle fixed plots (20 m²), and analyzed the floristic composition and species development (survival and individual height -H, diameter at breast level- DBL). Species establishment was measured by emergency (density of plants) and natural regeneration (density of natural regenerates). To determine species-fitness we applied a conceptual framework based on means (μ) and standard deviances (SD) of annual increment of H, DBL and survival for species development and establishment (%emergency, %regeneration). We attribute notes from 1 (μ -1SD) to 4 (1 (μ +1SD) and the sum of all notes and species were classified as low (<5) to high (>15) fitness. Only *Mabea fistulifera* showed high fitness for direct seeding and from the 68-sowed species, 23 (34%) had potential for direct sowing. The selection of fewer small-seeded-species with good performance may be an important factor to establish the beginning of the restoration.

T22-P17 - Richness and seed biometry of zoochoric species on restoration sites at the Brazilian Atlantic Forest

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Dispersal is a crucial process for conservation and restoration of plant diversity in tropical forests. We compared the number of zoochoric species and seed biometry among a planted forest (PLAN/ 20 years old), a naturally regenerating forest (REG/ 25 years old) and an old growth forest (FO/ more than 60 years without disturbance), to verify if the ecosystems modified by humans recovered the zoochoric species richness of the pristine Atlantic Forest (Poço das Antas, RJ, Brazil). We found a total of 262 zoocho-

ric species, with 94 at PLAN, 72 at REG and 225 at FO. Using vouchers deposited at the botanic garden herbaria (RB), we measured fruits and seed sizes (length, width and weight) and quantified the proportion in each size class (0-3mm/3.1-6mm/6.1-15mm/15.1-30mm/>30mm) in each forest type. Richness of zoochoric species was higher in all seed sizes in FO. Proportion of propagule sizes did not differ among forest types, except in the class from 6.1 mm to 30 mm length, that was higher in FO compared to PLAN and REG. Additionally, the upper size class (fruits >15.1 mm) was recorded only in FO. The lack of particular groups of seed dispersers is likely constraining the arrival of large propagules to the planted on spontaneously regenerating forests, altering by this way the natural successional processes and influencing the future species composition of these forests.

T22-P18 - Using drones for characterization of areas degraded by gold mining in the Peruvian Amazon

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Drones or Unmanned aerial vehicles (UAVs) can provide new ways for planning and monitoring forest restoration projects in the tropics, with consequent savings in time and money as well as much-improved data collection. Characterization of deforested and degraded areas as a previous step to reforestation usually requires a lot of time and effort of several people in the field. In this study, we sought to develop an effective method for characterizing and classifying areas degraded by gold mining, and for planning field forest restoration experiments across the landscape in Madre de Dios, southeastern Peruvian Amazon. Using small UAVs, we collected imagery from 10 different sites summarizing a total of 15 ha of areas degraded by gold mining. The drone used for the characterization of the areas was the DJI-PHANTOM 4™ model. We used Agisoft PhotoScan 1.2.6™ to elaborate orthomosaics for each of the sites, and then eCognition Developer 9™ for image segmentation and classification. We consistently found that the classes identified in areas degraded by gold mining are repeated throughout the landscape in other areas where mining operations were carried out with suction pumps. Regarding reforestation planning, we also developed a graphical 3 x 3 m spacing grid representing seedlings to be planted on each of the classes identified: a) bare soil; b) gravel mounds; c) flood zones; and d) natural regeneration. One month after planting, surviving individuals were also drone-mapped in order to evaluate species survival rates and further monitor of plant growth and restoration outcomes.

T22-P19 - Initial survival of 30 woody species in a reforestation experiment established after gold mining in the Peruvian Amazon

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Within the wide range of forest degradation drivers, gold mining as appears to be one of the most aggressive and difficult to restore due to the magnitude of its environmental impacts. However, there are still few studies on reforestation after gold mining in tropical forests. In this study, we evaluated the initial survival of 30 woody species in a one-hectare reforestation plot established in Madre de Dios, a prolific biodiversity region experiencing an important gold rush. A total of 1,167 seedlings from 30 species were planted in three reforestation subplots of 0.35 ha each. Fifteen days after plot establishment, the seedlings suffered a temporary flood where many of them were submerged for more than a week. One month after planting, seedlings survival and height were measured. Drones were used to build orthomosaics for assessing the spatial distribution of surviving individuals across the plot. Our results revealed that seedling survival rates varied significantly across species; significant correlations were found between survival rates and height of some species, however, greater heights are not necessarily related to high seedling survival rates after the flood. According to the orthomosaic, no particular areas were found to have an influence on seedlings survival rates. This study show the importance of using multiple species in order to assure high seedling survival rates in areas degraded by gold mining.

T22-P20 - The fate of exotic species in tropical forests undergoing restoration

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Exotic species are often mixed with native species when ecological restoration is based on planting nursery-raised seedlings. The question that arises is: what happens with the exotic species along the successional trajectories of tropical forests undergoing restoration? To answer this question, we assessed the proportions of native and non-native species planted and naturally regenerating in a chronosequence (6 to 53 ys) of 21 Atlantic riparian forests undergoing restoration in southeastern Brazil. We tested two alternative hypotheses: 1) exotics tend to dominate the communities, and 2) the natives tend to dominate the communities over time. We assessed the proportion of exotic species and individuals among plants in natural regeneration over time and also the proportion of exotics among the species planted compared to their proportion among the young plants spontaneously regenerating in each site. Among the species spontaneously regenerating, 46% resulted from native species planted, 16% from exotic species planted and 38% were immigrating native species (not planted). We found the proportion of native species increasing, while the exotics lose space in the communities over time. None of the sites presented a proportion of exotics in the regenerating community higher than the proportion in which they were planted. As a rule, therefore, the native species planted as well as those arriving from the regional species pool take advantage over non-natives in these forest undergoing restoration. The biotic and abiotic filters driving the community assembly are making the restored forests more similar to the native forests over time.

T22-P21 - Dynamics of natural regeneration in seedling planting in the Amazon: Rapid colonization by pioneer species

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Colonization by pioneer species is important to start ecological succession in degraded areas that are stagnated and covered by exotic grasses. In the Amazon, fallow pastures can develop in two ways, one dominated by *Cecropia*, and another by *Vismia*. Restoration efforts must create mechanisms which break the barriers to natural regeneration and allow the ecological succession to take place. Our goal was to analyze natural regeneration dynamics and the development of seedlings in the Amazon. We assessed nine seedling plantations aged between 6 and 42 months, located in the riparian zone of the Madeira River, within the influence zone of the Jirau Hydroelectric Dam, Porto Velho-Rondonia, Brazil. In each plantation, we installed five circular 10-m plots, where we sampled all tree individuals with heights over 30 cm, in August 2014/2015. We analyzed seedling performance in terms of growth in height, diameter, and mortality. Plantations presented high density of regenerants after only 18 months, and reached a richness of 45 species and tree cover of 65% after 42 months. The main colonizing species included *Cecropia purpurascens*, *Trema micranta*, and *Solanum grandiflorum*. Colonizing species arrived mainly through seed rain promoted by birds and bats. The presence of secondary forest patches close to the plantations assisted the rapid colonization of these areas, the decrease of exotic grass cover, helped attract dispersers, and improved the conditions for ecological succession. Seedling planting adds to the diversity of species, and pioneer species are important for soil covering and litter production, which improve microclimatic conditions.

T22-P22 - Climbing plants resprouting after cutting in a degraded semideciduous seasonal forest

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Degraded tropical forests usually have the proliferation of climbing plants which inhibit forest recovery into an expected successional trajectory. One action commonly recommended to restore these forests is to cut abundant climbing plants. However, few information is available on the best season to cut the stems. This study aimed to evaluate the sprouting of climbing plants cut in a degraded tropical forest fragment, located at Vassununga State Park (21°42'S and 47°34'W), within the Atlantic Forest, Southeastern Brazil. Climbing plants were cut in the rainy or dry season, and after three months, we evaluated percentage of

resprouting, and sprouts number and length by species and by season. Most of the climbing plants and species sprouted after cutting. In the rainy season, we found 59% of sprouting, with a mean of 3.9 sprouts per plant and 45.48cm of sprouts length. In the dry season, 52% of the plants sprouted, with a mean of 4.2 sprouts per plant and 47.36cm of sprouts length. Sprouting after cutting varied according to species. The species with the highest mean number of sprouts after cutting was *Fridericia triplinervia* with 14 sprouts, followed by *Acacia plumosa* with 11.6 sprouts. We found no effect of the season of cutting on sprouting capacity and sprout growth. Thus, other factors beyond climbing plants resprouting should be taken into consideration to define the most cost-effective season to cut abundant climbing plants in tropical degraded forests.

T22-P23 - A quantitative approach for species selection in ecological restoration of seasonal forests

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The classification of species into ecological groups enable their selection for the restoration of degraded areas. The aim of our study was to identify species with ecological restoration potential along the forest development. A 4.0 ha restored area with high density (10,000 plants/ha) and diversity (142 species) was monitored in 120 permanent plots of 12.5 m². For 5 years, we evaluated growth (height- H, stem diameter height- SDH) and survival (S %). We determined annual periodic increment (IPA) for growth variables and defined a suitability index based on species responses to competition and survival. Species were classified as: (a) inapt- high mortality rates (>50%) until 15 months; (b) facilitative - with less than 50% of survival in the 45 months and (c) structural - with more than 50% of survival at 45 months. After that, we classified structural species using a setting of scores from 1 (low survival and growth) to 4 (high survival and growth) based on IPAs and survival. We assigned suitability scores for 54 species being 8 of high, 25 of average, 14 of regular and 7 of low suitability. *Erythrina mulungu*, *Senna multijuga* and *Solanum mauritianum* were classified as facilitative. In Brazil, these species present high density and frequency in seasonal forest restoration. Their precocious exit from the assemblage causes the continuous occurrence of gaps and the returning of the weed establishment over time.

T22-P24 - Influence of biotic factors on survival of seedlings of native species in ecological restoration experiment of riparian forests, Cerrado

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The objective was to study the effects of biotic factors on seedlings survival of riparian forests species from central Brazil. The experiment was set in a complete randomized design, with three treatments and three replicates, in December 2011. The main treatments were Islands planting 5x5 m (T1), Islands planting + artificial perches (T2), and 'filling' and 'diversity' planting lines (T3). The experiment was evaluated annually from January 2012 to January 2016 for survival rate and plant development through ANOVA. The influence of the stem and foliar herbivory, absence of leaves, sprouting, and resprouting on survival was based on cluster analysis and Test t. The survival of planted seedlings was greater in the two first years, with a reduction of 30% (T1 and T3) to 40% (T2). The species were classified in three groups based on similar characteristics and treatment responses: Group 1 - species with low survival (<50%) and with greater stem and leaf herbivory; Group 2 - species with high survival (>75%) and lower herbivory stem, few budding and resprouting, but moderate foliar herbivory; and Group 3 - species with high survival (>75%), lower stem herbivory and greater foliar herbivory, but good sprouting and resprouting. The factor that mostly affected the survival was stem herbivory. The characteristics of the species (for example: *Alibertia macrophylla*, *Aspidosperma parvifolium* and *Tibouchina stenocarpa*) belonging to the Group 3 can be recommended primarily for restoration.

T22-P25 - Contribution of artificial perches to richness and abundance of seed rain in a degraded area of the Atlantic Forest

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Conventional planting techniques can generate low diversity forests. To overcome possible failures in restoration terms, nucleation techniques have been used and been effective in communities restoring. Artificial perches are used for resting, shelter and foraging, hence causing greater seeds deposition associated with birds feces or regurgitation. Considering the difficulty of the zoocoric diaspores arrival in abandoned pastures areas, perches presence can contribute to increase seed supply. Our objective was to verify the efficiency of artificial perches on the seed supply in the Serra de Inhoaíba, Rio de Janeiro, Brazil. In a reforestation area implanted on an abandoned pasture, 10 perches separated by a 30 m distance were installed. Two collectors of 0.5 m² were allocated under these perches and others were set in a control area (without perches). Seed rain was collected fortnightly over five months (April to September). The 400 samples were screened and identified at species/genus level by specialists. Data were analysed through t test and Mann Whitney tests, depending on the data distribution. Artificial perches contributed significantly to seed supply in the area. The diversity was higher (n=46) under perches than in the control (n=17; t=-7.08; p<0.0001), as well as seeds abundance (t=-4.47; p=0.0008; perches= 4093; control=418). These results confirm the efficiency of perches in increasing richness and quantity of seed rain in areas to be restored. The effective contribution of perches to restoration, however, depends on germination and establishment of the seeds arrived.

T22-P26 - Bauxite mined areas restoration in the Atlantic Forest, Southeast Brazil

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Nearly 20% of protected areas in the Atlantic Forest are threatened by mining concessions, which may come into operation if the new Brazilian Mining Code (Código de Mineração) is approved, reinforcing the need to develop techniques for ecological restoration of forest ecosystems of this biome. Three adjacent areas of bauxite mining in process of regeneration, of 21 to 56 months, were evaluated, including its surrounding reference ecosystem. We tested whether these areas in its initial stage of succession had structural and functional attributes to allow the restoration of ecological processes observed in the reference ecosystem. Two component were analyzed: tree (Diameter at Breast Height - DBH > 3.2 cm) and regeneration (Diameter at Soil Height - DSH < 3.2 cm). The results show that initially there is a density increase in both components, as well as basal area and species richness increase in the regeneration component. In functional aspects, only the distribution of species richness by dispersal syndrome was similar to the reference ecosystem. In the reforested areas, pioneer species and widespread species prevailed. The recovery of species richness was noticeable, particularly in the regeneration component, but similarity in species composition in relation to the reference ecosystem was not detected. The small size of the mining areas resulted in short distances between points of the reforested areas and the source of propagules, therefore, variation in richness, diversity and density of individuals in regeneration component was not detected.

T22-P27 - Forest functional enrichment: cost-effectiveness of three distinct methods

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The reintroduction of lacking functional groups through enrichment plantings aims to increase the ecological interactions network, enhancing the chances of successful restoration outcomes. The reintroduction of these species on initial development stages can be strategic to increase restoration efficiency, since smaller propagules facilitate planting logistics and therefore reduce restoration implementation costs. We examine how enrichment plantings of six species perform considering three dif-

ferent development stages (methods): seeds, smaller seedlings (i.e. less than six months in plant nursery) and mature seedlings (i.e. more than six months in plant nursery). Selected species include palm, large-seeded and hard wood native trees, which are compromised functional groups within modified and disturbed landscapes such as our study area, located in the Atlantic Forest region. First, we compared these three methods considering the purchase cost of the propagules. After planting the seeds and seedlings on six year-old (average) forest restoration areas, we evaluated their survival. Preliminary results showed a mean survival of 10%, 30% and 61% for each method, respectively. However, the difference between seed and smaller seedling survival was not significant ($p=0.196$). We verify that seed cost is 84% lower while smaller seedling is 57% lower than the cost of mature seedlings. Our preliminary conclusion is that despite the higher survival of the mature seedlings, seeds and smaller seedlings' enrichment methods offer a significant cost reduction, representing the best cost-effectiveness strategy for functional enrichment within forest restoration areas.

T22-P28 - Applied nucleation as a strategy for forest restoration: Effects on colonization and occupation of the area

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Passive and active forest restoration strategies are often slow or relatively expensive, but with high returns and promoting benefits for decades. Restoration by purely passive restoration is achieved by depending on how much regeneration you have at the start. On other hand, active restoration chiefly by intensive planting of a large number of trees it's comparatively expensive when compared with passive restoration and agriculture with financial returns. Normally, the most efficient restoration strategies in terms of cost and effectiveness facilitate and complement natural succession. We tested applied nucleation for restoring forest in Brazil, to determine if it is more cost-effective than other restoration techniques. Applied nucleation mixes both passive and active forest restoration methods, and it is the phenomenon that begins from agglomeration of trees and the expansion of these for the rest of the area increasing the heterogeneity of habitats across landscapes and creating conditions that promote natural regeneration. We examined a 9-year old monospecific AN experiment established on abandoned pasture in a semi-deciduous, seasonal forest zone in Brazil. We planted five trees per nuclei. Each nuclei with just only one species of these: Inga, Jacaratia (both zoocoric), Albizia and Cordia (both anemocoric). We recorded the spread of the planted tree species, biomass, vegetation area index and density of recruits in areas around the nuclei. Albizia competed with herbaceous weeds better than Jaracatia, Inga and Cordia, which enhanced it colonization ability. Canopy characteristics and tree dispersal may therefore be good predictors of species performance in recruiting non-planted trees.

T22-P29 - Plantations for non-timber forest products for ecological restoration in transformed habitats: An initial evaluation of planting "copales" in Mexico

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Non-timber forest products (NTFP) contribute to the livelihoods and welfare of populations living in and adjacent to forests. Copal, an aromatic resin extracted from two tree species of the seasonally dry tropical forest, is an important NTFP in Mexico. It is obtained from two late-successional species (*Bursera copallifera* and *B. bipinnata*), so plantations may contribute to restore and enhance the conservation value of patches of secondary forests in transformed landscapes. We established two experimental plantations of these species in Morelos, Mexico, with the aim of comparing survival and growth of seedlings and cuttings. Plants obtained from cuttings were previously raised for two years in the nursery, while plants from seeds were either 3 month or one year old when transplanted. 20-40 plants from each species and propagation method were transplanted in each of two sites. After one growing season survival of cuttings (98-100%) was higher than that of seedlings, irrespective of the species, but 3-mo old seedlings also showed high survival in one site (71-83%), but low in another, lower quality site (0-8%). Mortality was due to either waterlogging (in the wet season) or withering in the dry season. One year-old seedlings performed better than 3-mo old ones, but differences in survival were slight in the high quality site (?10%) and larger (?50%) in the low quality one. It

is concluded that it is feasible to establish plantations of the two species, and cuttings should be preferred to seedlings only in less favorable sites.

T22-P30 - Direct seeding for tropical forest restoration: vegetation structure at 4-6-y old sites

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Direct seeding is expanding as a feasible alternative to forest restoration, especially for large-scale projects, but little is known about the processes of succession in direct seeded sites. Vegetation structure can indicate the success of the restoration, as the canopy formation at first, and regenerants density and richness to assure the successional dynamics. Our goal was to evaluate the structure of tropical forests established by direct seeding in 4-6-y old sites in the Xingu watershed, Mato Grosso state, Brazil. We sampled three 4-y, three 5-y and two 6-y old restored sites. Trees (10 cm DBH) were measured in 500 m² plots. Saplings (1.3 m and <10 cm DBH) were measured in 100 m² subplots and seedlings (0.3m H; <1.30m) in the 25 m² subplots. Seedling density decreased from 469 to 112 stems/ha and saplings from 94 to 30 stems/ha. Trees increased from 0.15 to 0.52 ind/ha. Total density of tree species was 7,400 ind/ha. The basal area was 9.0 m²/ha, with small variations between 4 to 6 y old sites. The canopy height was 6.9 m and the canopy cover was 85%. At 4-6 years a canopy is formed and the forest is regenerating, despite having few adult individuals. The direct seeded young forests are similar in structure to resilient fallows at the same age, except for a lower species density. To increase richness in these sites, a combination of direct seeding with seedling planting of a diversity of species in low densities could be used.

T22-P31 - Revising restoration techniques on the basis of monitoring in the Atlantic Forest, Brazil

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In landscapes of southeastern Brazil, a matrix composed of anthropic areas underutilizes the hydrographic potential to provide ecosystem services. Reordering the use and occupation of soil located upstream of the Cantareira System, a transposition of waters to the city of São Paulo, represents strategic action to guarantee water supply to 3.5 million people, but also introduces ecological corridors between patches of forest vegetation and carbon stocks. We assessed the composition and structure of forests being restored in the Cantareira System, to verify the effectiveness of the restoration techniques and to identify possible sources of disturbance. The Restoration Monitoring Application, a web system designed by The Nature Conservancy to provide easier collection of data from monitoring of vegetation restoration projects was applied, attending an ordinance in effect of the Secretariat for the Environment of São Paulo. Among the results achieved, we highlight the plant species richness and density of regenerating plants. The results suggest the technique of reforestation by planting nursery-raised seedlings in high density widely used in the region shall be revised. We recommend as priority actions: 1) monitoring restoration projects since their beginning to avoid improper or unnecessary use of techniques; 2) constant fencing repairs to avoid cattle impact; 3) assisted natural regeneration and 4) if necessary, planting shade trees to increase density and to accelerate the recovery process. These strategies can optimize the application of resources for restoration in that region.

T22-P32 - Native tree plantations can offer opportunities for recovering tree diversity in Atlantic Forest in Misiones, Argentina

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Tree plantations can facilitate the recovery of tree diversity in degraded landscapes. The Atlantic Forest is a diverse eco-region with only 7% its original area remaining today. About 40% of this area is in Misiones in a fragmented landscape with secondary native forest in a productive matrix. We evaluated if *Araucaria angustifolia* managed with long rotation age might be a good tool for recovering tree diversity. In twenty plantations older than 30 year we registered all woody species > 5 cm DBH (diameter at 1.30 m height) in 1200 m² circular plots. We estimated the percentage cover of native forest surrounding each plot in 300 m² by ISODATA method by LANDSAT 7 satellite images. We calculated rarefaction curves accumulating sampling sites and individuals in Vegan package in R software. All sampled plantations were surrounded by more than 20% of native forest. In 1.2 ha we found 40 species for trees (individuals >10 cm DBH) and 70 species of small trees (5-10 cm DBH). Species accumulation on the basis of individuals was higher for trees than for small trees. Well conserved forest in the studied region exhibit 70-80 tree species in 1 ha. Thus, native trees in plantations area reach a lower diversity than native forest while small trees diversity approximates better. However, rarefaction curves based on individuals suggest higher evenness for trees which exhibit lower diversity due to lower density. The management of *araucaria* plantations might be conducted to increasing small trees growth in order to reach higher tree diversity.

T22-P33 - Homogeneous stands of native trees: contribution to recover the structure and diversity of the Atlantic Forest

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Assessments of natural regeneration under homogeneous tree plantations, mainly eucalyptus and pine, have shown that planted forests can catalyse natural regeneration in the long term. However, few studies have evaluated the regeneration under pure stands of native species in tropical regions. We assessed 28 pure stands of 12 native species, from 24 to 49 years old, located in the States of São Paulo and Paraná, in Brazil, to verify how natural regeneration progresses under pure stands of native species and to analyse whether homogeneous tree plantings can contribute to recover the structure and diversity of tropical semideciduous forest. Since the stands were planted for restoration purposes, the understory was never cleared. We measured all trees and shrubs above 50 cm in height (planted or spontaneous), and counted lianas and ferns. Most stands showed higher or similar density of trees, shrubs and lianas compared with primary forests. However, basal area of trees from 5 cm DBH and density of ferns were lower than in the reference forests. The species planted still dominate the upper strata of the stands (DBH > 5 cm), but the regenerating communities are more similar to the species pool of tropical semideciduous forest, although the understory composition is different and species richness is lower if compared to the reference forests. These results indicate that pure plantations of native species can be a good strategy to recover tree density in tropical forest, but adaptive management can be required to foster species richness recovery.

T22-P34 - Initial growth of *Psidium cattleianum* in springs ecological restoration in the Atlantic Forest Biome, southern Brazil

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Vegetation cover in the surroundings of springs preserves water resources, biodiversity and the gene flow of wildlife. The present study aimed to evaluate the initial growth of *Psidium cattleianum* introduced in strategies to restore springs areas in the Atlantic Forest Biome, Rio Grande do Sul state, southern Brazil. The planting of 170 seedlings of different species was carried out in 2014, being 18 seedlings of *Psidium cattleianum*. The planting was done in lines with spacing of 3m x 2m. The variables evaluated were Total Height (H), Diameter at Soil Height (DSH), Initial Survival (%) and Relative Growth Rate (RGR). Monitoring was done at 90, 180, 270 and 360 days after planting (DAP). The species presented 100% seedlings survival. The RGR values for the height variable were 28.43%, 47.17%, 49.74% and 54.69%, respectively, for 90, 120, 270 and 360 days after planting. The DSH presented RGR values of 25.40%, 34.64%, 35.06% and 46.52% (90, 120, 270 and 360 days after planting, respectively). We conclude that *Psidium cattleianum* demonstrated potential to be used in ecological restoration in the study region.

T22-P35 - What is planted for restoring the Atlantic Forest? Taxonomic and functional profile of 978 projects

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Planting tree seedlings is a common technique of tropical forest restoration. Looking at the species planted in the restoration of a given region may provide important information on how key functional groups and species are being represented in relation to the flora of reference ecosystems. We evaluated the taxonomic and functional profile of tree species planted in 978 restoration plantings in the Brazilian Atlantic Forest, performed from 2002-2015. We compiled the list of more than 16 million trees supplied from nurseries for restoration plantings within the "Clickarvore" restoration program (SOS Mata Atlântica) and the density of tree species found in monitoring of other restoration plantings. We found 428 species in the plantings, which represents only 12.8% of the tree species of the Atlantic Forest. Only sixteen out of 1,544 threatened species (nine endangered and seven vulnerable) were found on the plantings. However, 96.7% of the plantations have at least one threatened species. Non-pioneer species represent 60.5% of the planted species, but 65.2% of the trees planted are pioneers. Nitrogen-fixing legumes species are 17.3% of the species and 19.2% of the trees planted while animal-dispersed species represent 51.7% of the species and 44% of the trees planted. Plantings are similar to reference forests for percentage of animal-dispersed trees but they have a lower percentage of animal-dispersed species. Next steps are evaluation of restoration plantings changes through time in tree species composition and the analysis of the representation of Atlantic Forest regional floras in those plantings.

T22-P36 - Can reproductive traits contribute to the success of ecological restoration?

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Direct sowing has been proposed as an alternative to planting seedlings because of its low cost. However, there are still few works with direct seeding that aim to select species that best respond to the technique. Therefore, we carried out a direct sowing study with native tree species of the Semideciduous Seasonal Forest in Southern Brazil (Serra do Sudeste, State of Rio Grande do Sul), aim to: i.determine the effects of reproductive attributes (mass, shape and water content of the seed) in germination; ii.to test the effectiveness of direct seeding in treatments with and without mulching, buried and non-buried seeds, and iii.advice for selection of species for ecological restoration. Seeds of 17 species were collected and tested in the laboratory

and 12 of them were sowed in the field. The traits were related to germinability, mean germination time and germination speed index for the species tested in the laboratory. In direct seeding, emergence, establishment, and survival were calculated and the differences between the three treatments were compared: buried with cover, buried without cover and not buried with cover. In the laboratory, the flattened seeds presented greater germinability and a higher rate of germination, and the interaction of seed form and mass was significant for germinability. In direct seeding, buried seedlings with mulch cover presented higher germination rates, but there was no significant effect for establishment and survival. Our study suggests that species with flattened seeds should be prioritized in forest ecological restoration and that, when buried, increase direct seeding success.

T22-P37 - Evaluation of native species for the recovery of riparian forest in the Botanic Garden of Rio de Janeiro

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The riparian forest is composed of vegetation on the banks of water courses with important ecological functions, and even legally protected, they have been a constant target of anthropic actions. In this way, these areas are a priority for recovery. The objective of this work was to test native species and planting methodologies to promote the recovery of a section of the riparian forest of Rio dos Macacos, located in the Botanical Garden of Rio de Janeiro - Brazil. For this, 14 tree species native to the Atlantic Forest were selected, considering their respective ecological and functional characteristics, being mostly biotic dispersion with economic potential. The work place is located in an urban area and the planting was carried out in an area of 836 m², where 315 individuals were planted in quincunco. The adopted spacing was 2 m between rows, where a climax species is surrounded by early pioneer and secondary species. Planting monitoring was performed every two months by measuring the diameter, height, crown cover and survival rate. The results show that of the 74 seedlings of *Euterpe edulis*, a climax species, 55 survived. This good result was attributed to the shading provided by the initial and pioneering secondary species around it, which is shown through analyzes of species growth, highlighting *Myrsine umbellata* and *Eugenia candolleana*. These results highlights the effectiveness of quincunx for the survivability of Climax Species and ratify the *Myrsine Umbellata* and *Eugenia Candolleana* as facilitating agents for restauration plantations.

T22-P38 - Direct seeding for tropical forest restoration: species composition and stratification in 4-6-y old sites

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Direct seeding is a feasible method to restore large areas because it is practical and cheap. However, little is known about the successional process of areas restored by direct seeding. A restoration project is being conduct in the Xingu watershed since 2006. These areas are being restored by sowing 20-40 native tree seed/m² interspaced with short life leguminous shrubs. Our goal is to describe the species composition of areas restored by direct seeding. We sampled three 4-y, three 5-y and three 6-y old restored sites. Trees (? 10 cm DBH) were measured in 500 m² plots; saplings (H ? 1.3 m and <10 cm DBH) were measured in 100 m² subplots and seedlings (0.3m ? H <1.30m) in the 25 m² subplots. We sampled 63 tree species. For seedlings the species that dominated were *Mabea fistulifera*, *Enterolobium schomburgkii* and *Hymenaea courbaril*. For saplings *Mabea fistulifera* was again the most abundant specie, followed by *Bixa orellana* and *Dipteryx alata*. For trees, *Tachigali vulgaris* was the most abundant species, followed by *Mabea fistulifera* and *Anacardium occidentale*. Although all species were seeded simultaneously, pioneer species are forming a canopy, while later successional species are occupying the lower stratum, assuring the successional dynamics of the restored forests. Nursery seedlings plantations at the same age form a dense and diverse canopy, but do not have stratification. Direct seeding established successional diversity but species composition is restricted to the good germinant species in field conditions, as large, low water content and thick coated seeds.

T22-P39 - Ecological restoration in the Atlantic Forest: The case of the urban forests of Rio de Janeiro

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The remnants of Atlantic Forest in urban areas, under constant anthropic pressure and reduction of their areas, are a challenge for public conservation policies. Ecological restoration actions attempt to reverse this scenario, and it is preponderant to evaluate the success and the need for interventions. The present study aimed to evaluate the success of restoration plantings located in degraded urban areas in the city of Rio de Janeiro – Brazil. For this, five areas were analyzed in the Pedra Branca Massif, three restoration plantings (R1, R2 and R3) and two secondary forest areas used as reference (FS1 and FS2). Plots with 100m² were allocated, and the height and diameter of individuals were measured with DBH \geq 5.0 cm. Species were identified and classified as to dispersion (biotic and abiotic) and shade tolerance (tolerant and intolerant). Principal Coordinate Analysis (PCoA) was performed to compare the areas in relation to the structure, floristic composition and attributes of these plant communities. The results indicate structural similarity between restoration areas and secondary forest areas, aggregating them, and low similarity of attributes. In terms of floristic composition, the area under restoration R3 was the only area similar to secondary forests. These results show that restoration areas are not following the expected standard for Atlantic Forest, making it necessary to enrich species of functional groups similar to the reference forests in order to guarantee a more stable, resilient and self-sustaining ecosystem.

T22-P40 - Comparison of the initial development of native and eucalyptus species in pure and intercropping models aiming at ecological restoration

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The Atlantic Rainforest in the southern region of Bahia and northern Espírito Santo States, Brazil, is one of the most diverse forests in the world, currently present in fragments in a landscape dominated by pastures. In this work, we aimed to compare the growth of native species and eucalyptus by evaluating three ecological restoration models: eucalyptus plantation in total area, with native replacement after commercial exploitation; eucalyptus intercropped with native species, with native substitution after exploitation of eucalyptus; and planting of native seedlings, alternating fast-growing and diversity species groups. Each model was installed in a range of 30 meters including the border, being evaluated five plots of 40 plants per treatment. We performed measurements of diameter at breast height (DBH) and total height at 12, 24 and 36 months after the implantation of the experiment. The height and DBH of eucalyptus trees were higher than those of native trees at all ages in pure or intercropped model. The eucalyptus height in the pure model compared to the intercropped one was higher at 12 months and lower at 36 months, and the DBH was higher in the intercropped model at 24 and 36 months. The height of native trees in the consortium was higher than in the pure model at 12 and 24 months, and there was no difference at 36 months. The DBH of native species did not differ between the models regardless of age. The better development of eucalyptus in intercropping increases the attractiveness of this ecological restoration model.

T22-P41 - High diversity direct seeding of trees to restore Tropical Forest: questions to be solved

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In recent years, an increase in using direct seeding as a method of forest restoration has been observed, since it presents lower costs of implantation compared to plant seedlings. In light of the growing global demand for tropical forests restoration, the development of low cost methods that can be applied on large scale has great ecological, economic and social relevance. We are evaluating whether it is possible to form, through high diversity direct seeding of Semideciduous Seasonal Forest trees, a young forest with a canopy of pioneer trees and to obtain a minimum density of juveniles that will drive the formation of a second canopy dominated by intermediate successional tree species. We selected and used 36 species in the direct seeding, including

all successional groups. Our results show that 3 months after sowing, 28 (77,78%) species emerged and are developing. However, the number of individuals found was low, representing 8% of the expected. More than half of this individuals is represented by 5 species: *Hymenaea courbaril* (15,45%), *Pterogyne nitens* (12,56%), *Chrysophyllum gonocarpum* (9,17%), *Peltophorum dubium* (8,69%) e *Mabea fistulifera* (11,59%). Among these species, *Mabea fistulifera* is the only one in the recovering group, the others belong to the diversity group. Field observations suggested that the exceptional summer, one with the highest precipitation amounts in the last 74 years, produced soil erosion, seed burring and probably avoid the seed germination and seedling emergence. A thin layer of mulch covering the seeds would be a possible solution to this problem.

T22-P42 - Crown architecture and shading efficiency of fast-growing trees: Suggestions for forest restoration practice

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The planting of fast-growing trees with a large crown is important to restore forest structure and limit grass cover in tropical forest restoration areas. It is because a large crown supposedly provides a good soil cover, shading invasive grasses. To evaluate if a large crown is an effective criterion in the choice of shading tree species, we related the crown architecture of six fast growing trees (*Citharexylum myrianthum*, *Croton floribundus*, *Croton urucurana*, *Inga vera*, *Peltophorum dubium* and *Senegalia polyphylla*) with their shading efficiency, in a two-year restoration planting, located at Itu-SP, Southeastern Brazil. We measured the horizontal and vertical crown area and the crown depth of each tree. Then, we correlated them with the photosynthetically active radiation (PAR) that pass through the canopy and with the leaf area index (LAI). Finally, we made an analysis of variance to compare crown variables among the species. Crown depth was the only variable that did not correlate with LAI and PAR. Vertical and horizontal crown area are positively related to LAI and negatively related to PAR, suggesting that a large crown is a good indicative of soil shading by tree species in tropical forest restoration plantings. *Croton urucurana* presented the best values for crown variables related to soil cover and *P. dubium*, the worst, with the higher value of PAR passing through the canopy. Studies about crown architecture of trees already used in restoration planting as shading species should be performed for a reevaluation of the tree species considered as the best shading.

T22-P43 - Comparing the efficacy of planting tree seedlings and natural regeneration to restore the Brazilian Atlantic Forest

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Descriptors of forest structure (grass cover, tree canopy cover, basal area and height) and ecological processes (recruitment of new individuals) are mostly applied to monitor the success of planting tree seedlings and natural regeneration methods of restoration. Which of these methods give the best results? We are not aware of any investigation comparing the efficacy of such methods on large scale. To answer this question, we compared the results of these restoration methods applied to 380 restoration projects: planting (124 projects summing up 227.020 m² of sampled area) and natural regeneration (256 projects, 165.720 m²). We assessed monitoring indicators of the regenerating vegetation after two months to seven years from the beginning of the project in the Brazilian Atlantic Forest. We applied covariance analysis followed by regression analysis to investigate which method would yield the best coefficient of slope (beta) of the descriptors for each method along time. Forest structure and processes differed significantly between the restoration methods over time ($p < 0.005$), except for herbs and canopy cover where age was significant but method wasn't. Mean height and recruitment were greater in natural regeneration, however, six-year-old planted forests had almost the same abundance of regenerating individuals. Herbs cover was lower and canopy cover was higher in natural regeneration (although without difference between methods), and only basal area was greater in planting. Natural regeneration is a promising restoration method because it's cheaper, quickly diminishes competing grasses, and forests are rapidly structured, but it depends of time after degradation and remnant fragments nearby.

T22-P44 - Selection of species for nucleation model based on crown projection and the ecological potential of the species for the restoration of riparian forests in the Cerrado

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Currently one of the great challenges for ecological restoration in the Cerrado is to control the expansion of exotic grasses. Proper selection of species increases the chances of restoration success. The aim of this work was to create criteria to select native species to compose the Anderson nucleation model (five seedlings), in order to improve the nuclei efficiency in controlling exotic grasses and increase the availability of habitats. The experiments were implemented in 2011 in three disturbed areas of riparian forests, Distrito Federal, Brazil. We used seedlings of 21 native species. The species were evaluated and the established criteria were: crown projection and the ecological potential for restoration (PER). After five years of monitoring, the crowns projection by species was calculated by measuring the smallest and largest crown. PER was determined by assigning values (1 to 9) to the species according to their ecological characteristics: successional category, fruit type, ability to attract fauna and crown projection area. The species that had the greatest projection were: *Croton urucurana*, *Myrsine guianensis*, *Tibouchina stenocarpa*, *Inga laurina* and *Tapirira guianensis*. These species we indicated to compose the four lateral seedlings of the Anderson model (spacing of one meter between seedlings). For the central seedlings we suggest the species of greater PER such as *Genipa americana*, *Alibertia macrophylla*, *Calophyllum BRAZILIense*, *Copaifera langsdorffii* and *Salacia elliptica*. The distribution of these nuclei in the field it is expected accelerate the restoration process by helping to control exotic grasses and increase the attractiveness of fauna.

T22-P45 - The restoration in Rio de Janeiro, Brazil: processes that causing the loss of diversity

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In Brazil the deforestation is more evident near of the Atlantic coast, where many process of restoration is occurring by natural regeneration and plantation of seedlings mainly. In the state of Rio de Janeiro there are currently about 20% of forests areas in different stages of succession. There is also increase in abandoned pasture areas that has been occurring in 60% of the state territory and actually are conducive to natural regeneration, but also to the fire. In some of these areas there are ongoing seedlings planting projects. These projects and the natural regeneration are important for the reforestation, but may cause future problems. For example, exotic species that was inserted into reclamation projects 130 years ago now is becoming dominant and invasive. The main point of this work was discuss about the low richness of natives' species in the new forests that have emerged in the last years and the extinction of species that not occurring at these places. Rio have been registered a mega diversity of trees and bushes, with about 7000 native species, many of these are rare or threatened, however, less than 10% of these species are produced by the nurseries and the same species produced has been occurring in natural regeneration. In this way, about 90% of the native species doesn't occur in new forests, with the risk of extinction isolated in small fragments. Thus, these species will go extinct before reaching the new areas unless they are produced and used in enrichment projects.

Restoration of Tropical Savannas and Grasslands

T19-P01 - Soil preparation and direct seeding of Cerrado savanna at Chapada dos Veadeiros National Park, Brazil

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Abandoned African grasses pastures are the main restoration scenario in the Cerrado, in which direct seeding has shown promising results for restoration. However the groundcover of invasive grasses remained high. We tested the effectiveness of three intensities of soil preparation for restoration of savanna in Chapada dos Veadeiros National Park, Goiás state - Brazil. All experimental plots were burned to reduce grass biomass and allow for mechanized soil preparation, then we tilled plots and applied three treatments, each one in six 20mX20m plots: no further soil preparation (T-low); 20cm tilling (T-medium); 40cm plowing (T-high). All plots were direct seeded with a mixture of 17 tree species, 2 forbs, 5 shrubs and 7 grasses. Twelve months after seeding we measured trees and shrubs density and groundcover using the method line-point intercept in different height classes (every 50cm) in 10 m² subplots. We found 29 species established reaching $7 (\pm 0.8)$ ind./m² for trees and shrubs. The native groundcover varied from 59.2 to 105.2%, mean= $80.1 \pm 15.3\%$ in the first height class; 4.2 to 43.2% mean= $20.8 \pm 10.3\%$ in the second and 0 a 3.2%, mean= $0.2 \pm 0.8\%$ in the last height class. Plowed plots (T-high) showed higher native species cover at 50-100cm height ($25.7 \pm 11.1\%$, $p=0.026$) and lower invasive grass cover ($12.1 \pm 10.3\%$, $p=0.02$) compared to other treatments (T-low, natives: $12.5 \pm 8.6\%$; invasives: $22.7 \pm 5.2\%$). Turning soil deeper by plowing and repeating it several times kills invasive grass seedlings depleting the soil seed bank, resulting in less groundcover, allowing for better establishment of native species.

T19-P02 - Losses and gains in the use of herbicides to control exotic grasses in Cerrado restoration

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Invasive grasses have been widely reported as a major obstacle in ecological restoration, by constraining the establishment and growth of target species and by occupying the ground layer, therefore usurping the niche of native grasses and forbs. The problem is particularly severe in the Brazilian savannas, where plant growth is naturally very slow, and competition posed by exotic grasses can be a biotic filter difficult to surpass. Herbicides have been recommended to solve the problem, but studies evaluating the positive and negative effects of these products on the plant communities are still scarce. We carried out an experiment (12 randomized replications for each treatment) to compare survival, growth and reproductive process of tree seedlings planted, as well as density of plants in natural regeneration if herbicides (trifluometil + glyphosate) are applied (H) or not (G) to control invasive grasses (*Urochloa decumbens*). After 12 months, canopies were 42% larger and the proportion of individuals reaching reproductive stage in H was more than double that observed in G. Density of plants in natural regeneration, however, equally decreased in both treatments, either killed by herbicides or eliminated by grass competition. By providing faster growth and earlier reproduction of the trees planted, herbicides accelerate the recovery of vegetation structure, anticipate the attraction of pollinators and seed dispersers, and the re-establishment of ecosystem services associated to these processes. Young plants in natural regeneration, however, can be killed by herbicides as currently applied, and these losses must be avoided in order to potentialize the gains.

T19-P03 - Native species for vegetation restoration in the Cerrado biome

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This study presents a list of 360 native species of wide distribution in the Cerrado biome, with the objective of providing support to the recovery actions of degraded areas in Areas of Permanent Preservation (APP), Areas of Legal Reserve (ARL) and Areas of Restricted Use (AUR). The 360 species are distributed in 71 botanical families and among the recommended species, 252 are for the recovery of the arboreal stratum and 108 species for the herbaceous-shrub stratum. The species selection was based on specialized bibliography and workshops conducted with researchers, led by Embrapa within the project Technological solutions for the environmental adaptation of the rural landscape to the Brazilian Forest Code. The inclusion criteria of these species were based on: 1) experiences in recovery work; 2) high seed productivity of the species; 3) the ease of obtaining seeds or seedlings in nurseries; 4) and especially in the economical potential and ecological impact to the areas to be recovered. This list is only the first step in order to facilitate actions to recover forest, savanna and grassland landscapes of the Cerrado biome. It is expected that the indication of these species may serve as a stimulus for the collection of seeds in natural areas, seed production through cultivation and seedling production in nurseries, since species of the savanna and field components of the Cerrado biome availability are rare in today's market.

T19-P04 - Initial mortality evaluation from Cerrado species planted one year after a wildfire

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The restoration of an area after disturbance is not a simple process, especially after a wild fire, where an anthropic strong intervention is necessary to overcome the barriers to return the area to a pre-existent condition or some stable state. Aiming to provide information for the restoration, this study had as objectives to evaluate the initial mortality in a Cerrado arborous species planting. Seedlings were planted in an area that has undergone a wildfire, located at Amália Hermano Teixeira Botanical Garden, south region of Goiânia - Goiás - Brazil. Seven species were selected for planting with different number of seedlings for each specie, being *Sterculia striata* St. Hil. Et Naud (15), *Cariniana legalis* (Mart.) Kuntze (09), *Hymenaea courbaril* L. (11), *Copaifera langsdorffii* Mart. (02), *Anadenanthera falcata* Benth. Speg. (10), *Handroanthus chrysotrichus* (Mart. Ex DC.) Mattos (05), *Dipteryx alata* Vog. (02). Mortality evaluation was done seven and thirty days after planting and re-planting. Total mortality of the individuals was 29.62% and it is considered as acceptable, since the average for restoration plantings is 30%. Some species stood out, because they did not show any mortality, such as *Copaifera langsdorffii* Mart. and *Handroanthus chrysotrichus* (Mart. Ex DC.) Mattos. *Anadenanthera falcata* Benth. Speg. was the specie that presented the highest mortality, fact that is explained by herbivory in most of the seedlings. Among the evaluated species *Copaifera langsdorffii* Mart. and *Handroanthus chrysotrichus* (Mart. Ex DC.) Mattos presented lower mortality rates and may be recommended for restoration after wildfires. Subsequent evaluations were planned, however, due to logistic and administrative issues of the Botanical Garden, could not be carried out, making impossible the long-term conclusions.

T19-P05 - Relative density and plant cover of eight fast growing species introduced by direct sowing

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One of the biggest barriers to establish forest restoration is to develop a community able to resist an invasion by alien grasses. These grasses can have a negative influence on germination and development of native species and this is potentialized in areas already dominated by them. Good soil preparation with plowing, reducing this grasses infestation, and sowing fast growing native species, promoting fast soil coverage, may prevent this (re) invasion. To test this hypothesis, we plowed four areas

(pasture lands) previously covered by invasive grasses and sowed fast growing native species (including legumes). The relative density (seedlings/seeds sowed) and cover estimations were measured 90 days after sowing. The experiment was installed in four permanent preservation areas at the Serra do Facão Hydroelectric Power Plant in Catalão - Goiás, Brazil. In each area, five fast growing native species (*Tachigali rubiginosa*, *Solanum lycocarpum*, *Guazuma ulmifolia*, *Solanum paniculatum*, *Senna alata*) and three fast growing legumes (*Cajanus cajan*, *Canavalia ensiformis*, *Crotalaria spectabilis*) were sown in 12 plots of 1.8 × 3-m per species. Relative density and plant cover were respectively: *S. alata* 36.09%/11.38%; *S. lycocarpum* 18.46%/2.90%; *G. ulmifolia* 2.92%/0.02%; *S. paniculatum* 2.53%/0.02%; *T. rubiginosa* 0.89%/0.06%; *C. ensiformis* 24.83%/7.71%; *C. spectabilis* 24.03%/14.56%; *C. cajan* 10.42%/1.09%. *S. alata*, *C. ensiformis* and *C. spectabilis* had a high relative density and soil cover in short time, representing better species to use in restoration projects. The other tested species showed low relative density and slower growth. Future assessments can show their potential long term.

T19-P06 - Woody species and strategies for restoration in the Cerrado biome

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The success of native vegetation reclamation depends upon the knowledge about the species and planting strategies/models best suited for the area to be recovered. This work suggests more than 200 native species with their physiognomies of occurrence for the Cerrado biome, associated to its ecological strategy of occupation (covering or diversity) and main categories of potential economic utilization for using in eight planting strategies/models. It aims to guide technicians and owners of rural areas on the choice of species and appropriate strategies for woody (forest and savannah) vegetation recovery of Cerrado biome. Strategies for restoration with woody native vegetation vary from passive actions, as natural regeneration, to high intervention actions, such as those in Agroforestry Systems. Areas with greatest potential for natural regeneration have presence of regenerating seedlings, greater cover of native vegetation nearby and low presence of exotic and local competitors and it requires less labor and costs while areas with low potential for natural regeneration demand intense intervention and more expensive technics. All restoration action has risks and must be monitored and managed according to the expected results. These actions will indicate if your strategy was adequate and well conducted. Actions should start in small areas to support new decisions if something fails. To attend the law of Protection of Native Vegetation, these strategies can be applied in Brazil for Legal reserve (ARL) and Permanent Preservation (APP) areas.

T19-P07 - Seed germination traits: implications for the restoration of Brazilian savanna in a climate change

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In a climate change scenario, restoration ecology strategies must incorporate the different outcomes projected by recent studies, in order to mitigate its effects in the long term. Therefore, using propagules of regions with different climate conditions and seeds with distinct traits can be a good strategy to ensure species or populations adaptation. To improve the selection of populations more likely to accommodate to severe climate conditions in the Brazilian savanna, we compared different populations of native species to verify which seed traits are correlated with climate attributes, mainly temperature and water availability. We collected seeds of three species of trees in two different savanna areas that are distinct in terms of average annual rainfall and dry season, in the Northeast of Mato Grosso (humid savanna) and North of Minas Gerais (drier savanna), in Brazil. We compared seed germination traits (germinability, fluctuation temperature and water potential), morphological traits (size, shape and weight) and biophysical traits (water content). Germination traits were different among the two populations evaluated for all species. Seeds from the drier region germinated under higher temperature and lower water potential. There was no difference in the morphological and biophysical traits. These results indicate that populations of native species in Minas Gerais are already adapted to drought and higher temperatures, and the populations of Mato Grosso can be negatively affected by climate change. Therefore, using seeds from distinct locations could be a good strategy in future restoration projects in order to mitigate the impact of severe climate conditions.

T19-P08 - Cerrado restoration by direct seeding: Field establishment and initial growth of 75 trees, shrubs and grass species

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The coexistence of grasses, herbs, shrubs and trees characterizes savannas; therefore, to restore such ecosystems one should consider re-introducing all these growth forms. Currently, little is known about field establishment of most “Cerrado” (Brazilian savanna) species that could be used for restoration purposes. Most knowledge on restoration is focused on planting seedlings of tree species from forest physiognomies. Alternatively, direct seeding can be an appropriate method to re-introduce plants of different life forms to restore savannas. We evaluated the initial establishment success under field conditions of 75 Cerrado native species (50 trees, 13 shrubs, and 12 grasses) in direct seeding experiments in four sites in Central Brazil for 2.5 years. For that, we tagged and measured tree and larger shrub species and estimated ground cover by small shrub and grass species. Sixty-two species became established (42 trees, 11 shrubs and 9 grasses) under field conditions. Thirty-eight of the 48 tagged species had relatively high emergence rates (>10%) and 41 had high seedling survival (>60%) in the first year. Among grasses and small shrub species, *Andropogon fastigiatus*, *Aristida riparia*, *Schizachyrium sanguineum*, *Lepidaploa aurea*, *Stylosanthes capitata*, *S. macrocephala*, *Achyrocline satureioides* and *Trachypogon spicatus* had the greatest initial establishment success (up to 30% soil cover). These and other shrub and grass species are indicated for restoration projects within grassland and savanna physiognomies within the Cerrado. They can be used as early ground cover, structuring the community and helping to control the colonization of invasive grasses.

T19-P09 - Performance of the Cerrado native grass *Trachypogon spicatus*, under different nutritional treatments

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The Cerrado biome harbor a great variety of plant communities with great representation of gramineous plants. Despite its high diversity and endemism, this biome is widely degraded. Considering the vast area to be restored, studies with native species are extremely necessary. In a first approach to the problem, we experimentally assessed the differential survival and growth of the native *Trachypogon spicatus* grass in 6 different substrates: (1) Rupestrian grasslands soil (RGS); (2) RGS + liming; (3) RGS + liming + Nutri; (4) Cerrado soil (CS); (5) CS + liming; and, (6) CS + liming + Nutri. A total of 50 individuals of *T. spicatus* were collected and assorted by similar weight and size. Seedlings of the same genotype were grown in 1 L plastic pots under the different treatments. Plants were irrigated twice a day during 120 days, and subsequently, the survival rate, shoot and root size and leaf number were measured. Survival increased with the Nutri addition in CS (66%) and CS liming (64%). The Nutri addition reduced 42% the plant survival in RGS, and 34% in CS. Plant growth did not change significantly between treatments. On the other hand, the number of leaves was significantly higher in plants without nutrients ($p < 0,001$). We found a positive correlation between shoot and root size. As greenhouse experiments differ largely from field conditions, the next step shall be a large scale field experiment on the potential of this species in the restoration of degraded Cerrado area.

T19-P10 - Restoration of abandoned pasture with direct seeding of native species.

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Direct seeding of 36 native woody species of Cerrado was performed in two areas of Neossolo Regolítico on abandoned pasture surrounding the gallery forest at the Entre Rios Farm, Federal District. Seedling establishment was evaluated after a three years period in a gently sloping area (GSA) and in a more tilted and eroded (TEA) area. In each (100x50m), sowing was carried out in small pits (0,30cmX5cm), in December 2013, with commercial substrate for nursery seedling production to promote initial conditions for germination and seedling

emergence. These pits, spaced at 1x1m, were distributed in 36 lines of about 100m each, parallel to the gallery forest, totaling 2.520 pits. Each pit received up to 10 seeds per specie, depending upon success of species germination rate in the laboratory. Seed dormancy was not broken to consider species characteristics in restoration environment. After three dry seasons (36 months) species that showed better survival rates (>30%) in GSA was: *Acrocomia aculeata* (53,57%), *Hymenaea courbaril* (52,14%), *Eugenia dysenterica* (44,28%) and *Tabebuia aurea* (32,38%) and in TEA were: *H. courbaril* (50%) and *E. dysenterica* (32,38%). After the 36 months evaluation period GSA presented established saplings of 29 species and TEA 28. In general, most of species present low survival rate, but these results are highly significant if we consider the natural low woody species density of the typical vegetation of the area (Cerrado Ralo or Campo Sujo) and the carrying capacity of the poor and shallow soil conditions of the restored area. (Projeto Biomas, ProIC/DPP/UnB).

T19-P11 - Temperature fluctuation influences seed germination in Cerrado grasses: Lessons for restoration of open savannas

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The Cerrado comprises a mosaic of vegetation that varies from grasslands to woodlands, being the herbaceous layer dominant. However, the restoration programs of the Cerrado usually use woody species and exotic grasses, mostly due to the challenges in germinating native grasses. Therefore, this study aims to evaluate the germination of native grasses, using daily temperature fluctuations, since most of grasses have physiological dormancy. Seeds of 9 species were collected in the field, placed to germinate in germination chambers simulating thermal fluctuation of the day (19°C to 55°C), for 45 days (25 seeds/replicate, 4 replicates). Control seeds were kept in room temperature for the same period. After treatments, seeds were put to germinate for 30 days (27°C, 12/12h-light) and non-germinated seeds were tested for viability with tetrazolium tests. Germination percentages were low for all study species, except for *Andropogon* sp, *Aristida riparia* and *Gymnopogon foliosus*, which showed germination >50%. For *Aristida megapotamica* and *Andropogon bicornis*, the viability percentages were lower than 40%, and *Sporobolus aeneus* showed 50% of viability. Only seeds of *Loudetiopsis chrysothrix* showed a significant increase in germination when exposed to temperature fluctuation, with 26% increase in relation to the control ($p=0.03$). For all other species, the treatments did not change germination percentages. Our results showed that most of the study species did not present physiological dormancy and *Andropogon* sp, *A. riparia* and *G. foliosus* could be used for restoration. Thus, further experiments should be carried out in order to understand the mechanisms involved in the dormancy breaking of grass species to be used in restoration projects in Cerrado.

T19-P12 - Germination of three Fabaceae species after direct sowing: propagule beneficiation differences affect seedlings emergence

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Seed traits and sowing procedure shall be considered for selection of the most efficient method for establishing species in the field. Seed cleaning that increases germination for seedlings production can have negative effects when seeds are directly sowed. We evaluated the effect of propagule quality on emergence and germination of three Brazilian savanna trees (*Dipteryx alata*, *Tachigali rubiginosa* and *Vatairea macrocarpa*). For each species, 100 propagules per 1-m² plot were sown in four plots per treatment, being: perforated, intact and random fruit (perforated+intact), intact and scarified seed for *T. rubiginosa*; intact and random fruit, and intact seed for *V. macrocarpa*; and fruit and intact seed for *D. alata*. Emergence was evaluated after 15, 30, 45, 60 and 90 days. Intact and random fruits of *T. rubiginosa* showed emergence peak at 90 days and germination ($3\pm 3\%$, $M\pm SD$) was 15% lower than intact seeds (18 ± 7); the other two treatments did not germinate. *V. macrocarpa* intact seeds showed emergence peak at 30 days and germination (16 ± 11) was 35% lower than intact and random fruits (51 ± 12), fruits had emergence peak between 30 and 45 days. *D. alata* intact fruits showed an emergency peak at 45 days and germination (72 ± 13) was 26% higher than intact seeds (46 ± 5), which had its peak between 30 and 45 days. Fruit direct sowing of *V. macrocarpa* and *D. alata* showed higher germination, not being necessary to remove the seeds from fruits. While removing the seeds from fruits and sowing directly without scarification provided the best results for *T. rubiginosa*.

T19-P13 - Burning to restore reproductive processes in old-growth cerrado grasslands

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Ecosystem restoration goes beyond introduction of plant species in degraded areas. In a world of constant change, restoring ecological processes is crucial for keeping ecological systems resilient. Decreasing fire frequency in fire-prone ecosystems has strong impacts on their dynamics, altering reproductive processes that drive mortality and recruitment rates. To address this issue, we performed experimental fires in old-growth cerrado grasslands, where fire was suppressed for at six years or more, and woody encroachment is progressing. We recorded phenological processes in 58 species (grasses, forbs and subshrubs) occurring in burned and unburned plots (at least 20 individuals per species in each condition) over six months after the experimental fire. In the burned community, 62% of individuals sampled flourished, in contrast to 19% in unburnt plots, demonstrating a strong relationship between fire and sexual reproduction in cerrado grassland ($\chi^2 = 473.77$, $df = 1$, $P < 0.0001$). Fire induced reproductive processes in 79% of the species, from which eight showed total dependence on fire for sexual reproduction (six grasses, one subshrub and one forb). These results highlight the importance of fire for recovering important processes in old-growth cerrado grasslands where fire has been suppressed, such as community and population dynamics, sexual reproduction and thus enhancing genetic diversity and avoiding gene erosion and species extinction. Restoring fire regime is therefore crucial for maintaining old-growth cerrado grasslands and their biodiversity.

T19-P14 - Direct seeding of Cerrado tree species: Effects of weed competition control and consortium with native grasses

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Understanding the ecological filters constraining plant species establishment is of great importance to improve restoration techniques. In the Brazilian Savanna (Cerrado), weed competition, especially with exotic grasses, is often mentioned as a strong obstacle to the establishment of native species. We investigated whether consortium with native grasses (direct seeding) and / or controlling weed competition can foster success of direct seeding of tree species, in a field experiment (factorial in randomized blocks design) with the following treatments applied to 11 tree species (100 seeds per plot): i) controlling weed competition, ii) consortium with native grasses + controlling weed competition, iii) consortium with native grasses, and iv) control. We evaluated the emergence and establishment of tree individuals over seven months and quantified the ground cover by native grasses or weeds. The native grasses neither influenced germination of native trees nor constrained weeds colonization. The establishment of *Aegiphila verticillata*, *Platypodium elegans* and *Copaifera langsdorffii* was hampered by weed competition. The other eight species were not influenced by the treatments, with *Dipteryx alata*, *Hymenaea stigonocarpa* and *Mabea fistulifera* presenting the highest percentages of establishment. Although direct seeding may be successful for some species even without controlling weed competition, in most cases germination was very low and weeds posed a strong filter constraining seed germination and seedling establishment. Light competition seems to be the mechanism behind this negative effect, since native grasses, with low ground cover (80%), did not exert any inhibitory effect on germination and establishment of the arboreal species.

T19-P15 - Seed harvesting period of native species for environmental recovery in the Cerrado Biome

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The Law of Protection of Native Vegetation (12.651/2012) established the need of mapping and characterize the vegetation cover of rural properties as a means to promote its environmental regularization. One of the main bottlenecks to promote environmental recomposition of degraded areas is the availability of seeds and seedlings of native species. Thus, it is essential to dis-

seminate information on native species, such as the time of production of fruits and seeds, in order to guide public policymakers focused on sustainable rural production, as well as farmers, technicians and nurseries regarding the collection period of fruits and seeds. The objective of this work is to provide the monthly fruit and seed collection period for 330 native tree and shrub species for the recomposition of Permanent Preservation and Legal Reserve areas of the Cerrado biome. The species suggested were based on a survey conducted by Embrapa, in partnership with the Ministry of the Environment. Information about the months of collection of the fruits and seeds of each species were collected in the specialized literature on plants of the Cerrado biome, based on the maturation months of the fruits of the species. This information was validated in workshops with experts and also based on herbarium database, with a focus on species of the center-west region of Brazil. Most tree species showed a peak of seed production at the beginning of the rainy season (August-November). The shrub-herbaceous species showed a fruiting peak during the dry season (April-September).

T19-P16 - Effect of depth and shading on *Handroanthus impetiginosus* germination using direct seeding technique

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Direct sowing method has shown to be promising when compared to the traditional technique of planting seedlings, mainly due to the high cost of this technique. Although promising, some statements should be carefully studied, such as sowing depth and the most suitable environment for each specie, once luminosity, soil conditions, and soil surface moisture are determining factors for the success of direct seeding. This study had as objective to determine the effect of depth and shading of *Handroanthus impetiginosus* seeds (Mart. Ex DC.) Mattos collected in the green areas located at Agronomy School that belongs to Federal University of Goiás (Goiania/Brazil). Seeds had no pre-germination treatment, and they were planted through direct seeding method in two different areas: full sun and shaded by the understory, in superficial depth less than 01 cm and in grooves with 02 cm depth. Manual weeding and ant control were done using artificial baits. A completely randomized design with 20 seeds in each of the 4 replicates was used. The average germination rate of the seeds in the superficial groove was 56.25%, while in the groove of 02 cm it was 15%, considering the sowing located in the understory. Seeds in full sun did not germinate. There was a significant difference between treatments, where understory sowing (depth <1cm) shows to be the more suitable for the specie.

T19-P17 - Direct sowing of herbs, shrubs and trees for restoration of Cerrado

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The Cerrado biome, Brazilian savanna, has been intensively converted into crops and pasture. To restore savannas, it seems necessary to quickly establish an herbaceous layer that would prevent the recolonization of invasive exotic grasses. In this study, we direct seeded 11 species of trees, 2 shrubs and 8 grasses, and tested 3 densities of *Stylosanthes capitata* and *S. macrocephala*, a commercial native forage, used as cover plant. We observed the development of the seeded community over 27 months. Seeds were sown in seven strips of 10×100-m, splited into the three sowing densities of *Stylosanthes*. The treatments didn't promote differences in soil cover, differing only between sampling times. At the final of the 27th months, 22 species germinated, and there was 28% of bare soil, 28% of native species and 39% of exotic grasses. The final species density was 13 species/5m², and individuals density was 154 individuals/5m², from which 24 individuals/5m² were *Stylosanthes*. Herbs had the highest final density at the 27th month (70 individuals/5m²) and trees the smallest densities (32 individuals/5m²). Direct sowing is a good technique to introduce species from all strata of Cerrado formations, however, *S. capitata* and *S. macrocephala* don't produced a expected soil cover. A more efficient control of exotic species previously introduced for pasture is therefore required.

Restoration of Wetlands and Aquatic ecosystems

T18-P01 - Ecological restoration techniques in sustainable collecting of sphagnum moss in Chilean Patagonia

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Peatlands are a type of wetland that provide important ecosystem services such as products related to Sphagnum moss. This plant is used as a substrate in horticulture and it is highly demanded in international markets, which has caused an increase in its extraction, generating a serious environmental problem derived from the overexploitation of this resource. Given this problem, this work seeks to improve sustainable harvesting practices by evaluating the effect of the application of ecological restoration techniques on the establishment and growth of Sphagnum moss after harvest. Research is being carried out in three locations (Ancud, Dalcahue and Chonchi) of the Isla Grande of Chiloé, Los Lagos region, Chilean Patagonia. Experimental plots have been mounted in each locality constituted by four quadrats with sustainable moss harvesting. The first quadrat was maintained as a control and the following three were covered with reintroduced fragments of *Sphagnum magellanicum*. In addition, quadrat three was also covered with a layer of moss *Dicranoloma imponens* and quadrat four with branches of *Tepualia stipularis*. Preliminary results show that the protective layer, given by branches of *Tepualia stipularis*, has generated significantly better conditions for the establishment of the Sphagnum moss, measured as the appearance of new shoots. The results obtained are expected to generate better conditions for the regeneration of Sphagnum moss, reduce the waiting time between collecting periods, and protect the economic and environmental sustainability of the moss. FONDECYT de Iniciación N° 11150275.

T18-P02 - Can the restoration of the riparian forest bring back zooplankton functional diversity in an impacted reservoir?

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Riparian forests (RF) play important roles in reservoirs. Roots, sticks, branches and dead leaves can provide a substrate for colonization of algae and invertebrates, influencing aquatic biodiversity. Managers of Volta Grande Reservoir (Minas Gerais State, Brazil) made an effort to recover its RF, which are currently 10 and 30 years old. Here we tested the hypothesis that zooplankton functional diversity would be positively affected by the abundance of RF (here considered as the width of the RF), and that RF age would influence functional diversity due to higher niche availability. Zooplankton sampling was carried out between February/2013 and August/2014 in representative points of the reservoir land use (agricultural, industrial and restored RF). Our results showed that RF, together with environmental variables representative of land use around the reservoir, are important factors influencing not only zooplankton total biomass but also zooplankton community structure and functional diversity. Analysis of variance indicates that RF abundance and age explained 62% of the variation in the zooplankton composition structure and 35% of the variation in zooplankton functional diversity. Our results also indicated that RF associated with beds of the benthic macrophyte *Elodea* spp. had a structuring effect within the epibenthic cladocerans *Alonella dadayi*, *Ilyocryptus spinifer* and *Macrothrix elegans* besides epibenthic rotifers. Our findings suggest that the association of RF abundance and complexity (macrophyte association) can provide a key habitat for increase of zooplankton functional traits in impacted reservoirs.

T18-P03 - Saplings growth and survival of different regeneration guilds in the restoration of a hygrophilous forests, Southeastern Brazil

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Hygrophilous forests are hydric saturated environments and the knowledge of the species behavior in these areas is fundamental to the success of the restoration process. This study aimed to evaluate the survival and initial growth of saplings classified in regeneration guilds (pioneers, light demanding and shade tolerant) planted at Vereda do Acari (Chapada Gaúcha, Minas Gerais, Brazil). In January 2012, 7604 saplings were planted in 16 plots of 80 m × 40 m, with a watercourse located in the center of the plots. The individuals were measured quarterly, in height and diameter at the base of stem, for 15 months. The percentage of survival was calculated and the Analysis of Variance and the Tukey post-test were performed for growth and survival analysis. Survival varied between the guilds ($gl = 2$, $F = 8.42$, $p < 0.001$), with the highest mean in the light demanding climax group ($64.88 \pm 4.51\%$). Growth also varied in height ($gl = 2$, $F = 15.76$, $p < 0.001$) and diameter ($gl = 2$, $F = 38.46$, $p < 0.001$), where the highest growth average (14.35 ± 1.45 cm in height, and 2.89 ± 0.21 mm in diameter) occurred at shade-tolerant climax species. The light demanding species show accelerated growth and are inundation resistant. On the other hand, shade-tolerant species tend to allocate more biomass in the roots than the other guilds, which may have favored the growth of these species in the area.

T18-P04 - Stormwater to stream flow through surface storage and hyporheic flow

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Bergen County, New Jersey is voluntarily undertaking the restoration/enhancement of habitat at the Teaneck Creek Park section of Overpeck County Park. Historically, this area was a tidal freshwater marsh, but a tidal gate downstream of the site eliminated the site's tidal hydrology. Subsequent development and landfilling on the margins of the site has further degraded conditions. The surrounding development was designed and constructed to drain to the remaining undeveloped land. The purpose of the proposed restoration, is to restore the natural habitats of Teaneck Creek Park, including the restoration of wetland, riparian and stream habitat. The restoration includes re-grading the topography to intercept and create surface storage wetland features at multiple stormwater discharges from surrounding development. A regenerative stormwater conveyance (RSC) system will be constructed in the largest drainage locally known as the 'stormwater canyon'. Using the RSC approach, including elements of sand seepage wetland design, stormwater inputs will be held in wetland depressional features and soak into the ground and constructed seepage zones. Larger storms will flow overland, spreading across the site increasing contact area, reducing its velocity and increasing contact time, and be safely conveyed to Teaneck Creek. Stormwater becomes the hydrologic foundation for integrated stream and wetland systems that slow the flow of the stormwater, converting the high frequency storm events into hyporheic seepage flow capable of restoring and enhancing wetland and stream hydrology. The design recreates novel flow paths based on historic flow paths, and re-establishes a native wetland landscape. This approach will reduce peak discharges, increase the time of concentration, and infiltrate stormwater pulses into a hyporheic lens that will slowly deliver seepage to the constructed streams and ultimately to Teaneck Creek. By improving the site hydrology, water quality will be improved, with an overall effect of restoring riparian wetlands and establishing conditions for a diversity of native plant species. This project will be the first in the County and State to use RSC techniques to restore wetland, riparian and stream habitats, and will showcase the benefits of green infrastructure in managing stormwater inputs within a highly urbanized setting.

Restoration planning, setting priorities

T02-P01 - Quantification and valuation of ecosystem services to optimize sustainable re-use for low-productive drained peatlands

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Almost one-third of European peatland resource is situated in Finland, where more than half of the original peatlands have been drained to increase tree growth. However, 20% of the drained peatland area does not produce enough timber to fulfill commercial purposes. Their biodiversity is degraded, they may continue environmental loading to watercourses and act as greenhouse gas (GHG) sources. There are needs to use the low-productive peatlands in the production of bioenergy, timber and peat. Simultaneously, there are needs to restore the most valuable drained peatland habitats, which might recover towards their original state. The problem is that the impacts of different the different options on biodiversity, environment and economy are not yet fully understood and thus it is hard to give proposals for re-use actions for specific areas. The challenge is to develop mechanisms that can balance the conflicting demands on the use of the drained peatlands and to ensure their sustainable use. EU funded LIFEPEATLANDUSE (20132018)

T02-P02 - Prioritizing areas for forest landscape restoration based on water quality and quantity components in Mangará River watershed, Espírito Santo State, Brazil

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The State of Espírito Santo (Brazil) has committed to restore 80.000ha in degraded land. More recently, the state has been affected directly by the severe drought period, which impacts to the water supply system of cities. Restoring degraded land can contribute to minimize the impact of the lack of rainfall in the state. The ROAM (Restoration Opportunities Assessment Methodology) was applied in the State and one of the most important factor to promote restoration is the water quality and quantity. The SRD (Sediment Retention Delivery) and Water Yield models from InVEST were applied to identify the priorities areas for restoration. To assess the potential impact of natural restoration at a small watershed (Mangará River - 17500ha) was chosen to simulate three scenarios of vegetation restoration based on current landuse: 100ha, 500ha and 1.000ha. Selection of areas were based on those pixels that have higher SDR value within the watershed until to reach the established restoration area goals. The overall results demonstrated that by restoring land in 100ha, 500ha and 1.000ha, the total value of SRD are reduced by 8%, 16% and 19% respectively. Thus the method can be replicated in different regions to restore areas that are more relevant to improve the water quality while increasing the natural vegetation coverage.

T02-P03 - Knowledge gaps in the ecological restoration evaluations: A critical review and recommendations for the future

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Restoration initiatives increased around the world in the last decade in a range of areas characterized by different habitat types, methods, technology and empirical knowledge. Evaluations to know if effective restoration outcomes have been achieved are necessary to balance financial investments and ecological outcomes. Our goal was to identify the knowledge gaps concerning the assessment of the ecological restoration process. We conducted a systematic literature review to compile quantitatively the

most evaluated variables regarding restorations' outcomes across tropical regions. We found 265 references that were classified according to restoration method, specific restoration goal, response and explanatory variables. As response variables we considered richness, density, cover, biomass and composition, and for explanatory variables we analyzed landscape context, seed bank, site resources, invasive species and site disturbance. Much of the reviewed studies were empirically based on one or more reference sites (55.1%) and used active restoration methods (36%). The majority of the studies analyzed multiple response variables (77.4%), being species richness (62%) and density (40.4%) the most evaluated. Site disturbance (25.3%) and soil attributes (19%) appeared as the most frequent explanatory variables. According to this overview structural measures are the most used evaluation criteria. On the other hand, socioeconomic, functional traits, ecological processes and ecosystem services remain poorly investigated. Our results highlight the need of focusing on dynamic-related measures which are crucial in future studies to evaluate the effectiveness of restoration actions for achieving biodiversity conservation, long term self-sustainability and human well-being goals.

T02-P04 - Mapping of soil erosion vulnerability through geospatial analysis in Paragominas (Pará-Brazil).

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The lack of knowledge about natural limitations and resilience of soils can result in unsustainable use and, consequently, an increase in erosion, thus contributing to possible desertification. The study was carried out in the municipality of Paragominas, in northeastern Pará. The objective was mapping soil erosion vulnerability through geospatial analysis to assist ongoing socio-ecological strategies in the region. The study was based on the methodology proposed by Crepani et al (2001), which analyzed soil vulnerability to erosion through mapping of climatic variables, geological, geomorphological and pedological characteristics together with vegetation types. The data for each attribute and evaluated unit ranged from 1.0 (i.e. lowest potential erosion vulnerability) to 3.0 (highest vulnerability). Our results show that, with respect to high vulnerability, the geological attribute presented a 38% area of the municipality, followed by soil attributes (19% area), vegetation (9% area) and slope (2% area). With respect to the overall result 6% and 20% of the municipality has the highest and lowest vulnerability, respectively, whereas the remaining area was of low-moderate (27%), moderate (34%), and high-moderate (13%) vulnerability. The regions with higher vulnerability are related to greater slope areas, regions with exposed soils, gleysol and plinthosol types, in this way this evaluation can improve to decision making processing in management of areas.

T02-P05 - Green connectivity in the urban context - Development and comparison of two green networks in the city of Berlin

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This project focused on the Berlin districts of Mitte and Marzahn-Hellersdorf in order to identify potential connectivity of their existing Urban Green Spaces using the GIS methodology Least Cost Path (LCP) analysis. A categorical typology of UGS was developed from literature in order to assign numerical impedance values to each of the different land use types. As a result potential green networks with the lowest numerical impedance values were produced as planning suggestions to improve the connectivity of the network of the Urban Green Spaces in each district. Also areas which are not actually 'green', such as streets and railroad green proved to be important elements for connecting different core areas. Thirty percent of the path in Marzahn and 20% of the path in Mitte crossed areas which are considered typologically low quality green areas or 'no green' areas. Urban green in the form of private property also played an important role in both districts. Brownfields, as a land use type in the analysis, proved to be particularly promising for improving the network in Marzahn-Hellersdorf. It was possible to make suggestions for planning interventions such as integrating areas as brownfields as core areas and using innovative solutions like green infrastructure.

T02-P06 - Definition of a landscape level biodiversity conservation-restoration strategy supported by disturbance resistant regional forest species

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This study is based on floristic survey of forest fragments in anthropogenic landscapes dominated by intensive monoculture of sugarcane (São Paulo State, Brazil) for several decades. Our previous study revealed a significant remaining forest richness in these anthropogenic landscapes, suggesting a need to adopt strategies for conservation of this biodiversity. The hypothesis of the present study is: in a large spatial scale, the main tree species resistant to fragmentation can be indicated as key species in forest conservation and restoration in anthropogenic landscapes. With the presence data of arborescent species in forest patches we assembled a bipartite network “forest patches & species”. The closeness metrics indicated which species most connect fragments, while betweenness indicated which species link fragment groups. From these two results, we selected the most important species, which generated a list of species. These fundamental arborescent species may be useful in the installation of facilitative core for the ecological succession in forest restoration strategies. Thus, through network analysis we set a list of key species that must be present in the restoration projects of the Atlantic Forest. This same strategy can be applied in other ecosystems around the world.

T02-P07 - Integrating the ROAM's restoration diagnostic with the open standards for the practice of conservation in forest landscape restoration

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This study presents the use of the Open Standards for the Practice of Conservation (OSPC) as a support tool for the development of the restoration strategies as part of Restoration Opportunities Assessment Methodology (ROAM), developed by IUCN and WRI. This pilot initiative developed strategies using the theory of change approach of the OSPC for the first version of the ROAM for Paragominas municipality and the state of Pará, in the Brazilian eastern Amazon, coordinated by Imazon. Once the restoration diagnostic revealed the key success factors for restoration that were ‘not in place’, the conceptual model and the results chains were designed and restoration strategies were developed. They were included in a policy document to support the local government on the definition of its future forest restoration goal and the development of a business plan.

One positive aspect of this integration is that it provides a contribution to advancing with the planning phase of a ROAM. One challenge to be expected is based on the fact that not necessarily all restoration projects have a clear connection with nature conservation, as the OSPC have. Therefore, the use of the two methodologies combined might require a previous alignment of expectations.

It was found that this synergy between those two methodologies presents a high potential for integration. That is good news, considering the contribution that the OSPC can provide to the restoration agenda and vice-versa and because both tools currently present a capacity for global reach.

T02-P08 - Restoration planning for climate change mitigation and adaptation in the city of Durban, South Africa.

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Most large scale restoration projects around the globe are now planned to achieve biodiversity, ecosystem services and socio-economic benefits. However, effective planning of a large-scale restoration project is challenging, because of the range of variables that need to be considered (e.g. restoration of multiple habitats with varying degradation levels and limited conservation resources). A restoration planning tool, Robust Offsetting (RobOff), was used in a forest restoration project in Durban South

Africa, to demonstrate how to effectively plan restoration considering multiple habitats with varying levels of degradation, diverse restoration actions, limited budget and multiple benefits to be achieved simultaneously. To achieve this, three complementary restoration actions were modelled for a comparison with the current action (planting of 51 indigenous trees) used in the city: i) natural regeneration action; ii) carbon action; and iii) biodiversity action. Restoration costs as well as benefits in terms of tree diversity, carbon stock and employment were estimated. When restoration budget became more limited, resources were allocated to severely degraded habitat mainly to achieve employment benefit. When benefits were prioritized equally, the biodiversity action was recommended for restoring severely degraded habitat. Prioritising carbon stock influenced the selection of restoration actions in the severely degraded habitat, resulting in a trade-off between carbon and biodiversity. RobOff provides an effective planning solution for a large-scale restoration project by prioritizing where and how restoration should occur to maximise biodiversity, carbon and employment benefits.

T02-P09 - Landscape structural approach for the conservation of ecosystems in the Bogotá City

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The process of urbanization has transformed the natural resources and the ecosystem services in the cities and around urban centers in the whole world. Creating strategic areas that allow for ecosystem conservation and recovery of landscape connectivity is, therefore, desirable, in order to ensure the protection of biodiversity and to improve quality of life for humans. In the Capital District of Bogotá, Colombia, natural ecosystems vary according to a broad altitudinal gradient. This variation is considered by the Principal Ecological Structure of the city, which is the official system of protected areas, urban parks, ecological corridors and the Special areas of management of the Bogotá river. Recently, landscape studies in environmental planning in many countries have taken into account the fragmentation of native vegetation and the quality of forest remnants. Environmental planning has incorporated all the variety of structural elements of the landscape that represent clear or transitional boundaries formed by patches, corridors and matrix of native vegetation that facilitate the interpretation of the history and functions of natural ecosystem in the urban environment. Whereby these structural elements must be incorporated in the environmental planning for the monitoring the elements of the Principal Ecological Structure of the District of Bogota, that will allow the assessment of the efficacy of current environmental regulations, detection of the ecosystems most affected by human action, and will provide a guideline for ecological restoration in areas that must be protected. Ecological restoration, if well planned, can strongly contribute to re-establish connectivity and favoring biodiversity conservation.

T02-P10 - Preliminary diagnosis and governmental evaluation of the emergency actions and the environmental recovery program of the areas affected by the failure of Fundão Dam, in the Doce River, Mariana, Brazil

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The failure of Fundão Dam severely affected the Doce River in December 2015. Since then, Brazilian environmental agency, IBAMA, tracks the adoption of emergency measures to contain the waste volume from iron mining dumped on the watershed. The 43,6Mm³ of tailings affected water quality, vegetation and soil along the floodplain of the rivers, an area with about 2000ha. As part of the actions foreseen in the agreement between the government and the shareholders of SAMARCO - the company responsible for the mining complex where the dam was located - emergency measures were adopted with the objective of containing the waste deposited in the plains in order to allow ecological regeneration and subsequent recovery in these areas. The monitoring of these measures is part of Operation Águas, with 32 qualitative parameters registered as erosion control, surface drainage and biota resilience, in 83 tributaries of Doce River, located from the Dam to Risoleta Neves Hydropower Plant, the most affected area by the disaster. Based on a preliminary diagnosis and field observation, the data allow the evaluation of the effectiveness of actions and making recommendations for adjustment of the recovery projects under preparation. IBAMA has issued 03 reports and 71 notifications to guide the company in correcting failures and adopting complementary measures, which

must be attended in the execution phase of environmental recovery projects. The results suggest that IBAMA should monitor and validate performance indicators for this phase, to measure the level of recovery of the areas based on environmental services.

T02-P11 - Planning restoration: Identifying priority areas for improving the forest patch connectivity

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Spatial planning and forest conservation are related issues, which are also directly linked to urban and environmental planning. The increase in forest fragmentation is mainly due to the anthropic factor that has led green areas to become even smaller fragments. The goal of this work is identify priority areas for proposing the implementation of structural ecological connectors. Such techniques will be important for assessing and foreseeing a dynamic land cover process. The links between forest remnants will provide environmental recovery to regions that require active restoration. The study is carried out in Sorocaba, SP, Brazil. Priority areas for restoration were selected based on previous landscape ecology-related studies. Through geoprocessing, a model of Adequacy for Restoration (SIR) was developed. The integration between the collected data and the model revealed patterns in the matrix that pointed out regions that are priorities for restoration, being 42.5% of them for assisted restoration. Fragments greater than 50 ha were precedent to assign link distances (30-120 m). Nine priority areas were identified for implementing the restoration plan and proposing the structural design of ecological corridors. The model is not species-specific, and it focuses on the structure and functionality of the ecosystems. It allows a practical use of the maximum resilience potential of the area, while also being feasible and acceptable.

T02-P12 - Biophysical and anthropogenic drivers of tropical forest regeneration in human-modified landscapes: A review since 1990

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Recent initiatives at national and global levels have set ambitious restoration targets, particularly for forests. To restore forests at large spatial scales, it is necessary prioritize areas with higher natural recovery potential, where cost-effective solutions are viable and competition for land is reduced. The investigation of the drivers of forest regeneration may then provide the necessary knowledge for predicting regeneration potential in targeted landscapes for restoration. In this study we reviewed the importance of biophysical and anthropogenic drivers on natural regeneration of tropical forest at landscape levels. We performed a systematic review of published literature monitoring natural regeneration of tropical forests at landscape scales, and its relationship with some biophysical and anthropogenic drivers, from 1990 up to the present. A total of 36 studies were found, in which supervised digital classifications of satellite images and transitions matrix were the most common procedures used to estimate the increases on forest cover. The change of forest cover area and the Weight of Evidence were the most common methods to evaluate the importance of drivers on natural regeneration. Slope and proximity to primary forest were the main biophysical variables positively influencing natural regeneration, while altitude, distance to rivers, and distance to areas previously deforested showed a less consistent effect. Among the anthropogenic variables, distance to settlements and roads also positively influenced natural regeneration. Our findings may support the development of landscape prioritization models for implementing large-scale forest restoration in the tropics, thus contributing to the global restoration programs planned for the coming years.

T02-P13 - Comparison of different land degradation indicators: Does world region really matters?

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In 2010, the Convention on Biological Diversity (CBD) created a list of 20 objectives known as the Aichi Biodiversity targets to aid in the restoration of degraded ecosystems. Except for the United States, most UN member states have ratified the CBD. Among the targets set, there is a recent commitment to restore at least 15% of degraded ecosystems by 2020. To fulfil this target a crucial step is the development of non-biased prioritization methodologies to establish key areas for restoration. In every prioritization process, the selection of land degradation indicators is a fundamental component. However, data availability to compile such indicators relies on each country's economic capability, governance, internal politics, degradation level, reliable information and free access to data. According to the World Bank, there are 79 (36%) high income economies in the world from a total of 218 countries (including overseas territories). Therefore, only a select group of countries would potentially have the resources to compile all the information necessary to perform the prioritization process. In this work, our aim was to analyze and compare the indicators (e.g. land use/change, primary productivity, biodiversity loss, soil organic carbon, degradation level, social acceptance) in four world regions with different economic income, political and cultural background; Europe, Latin America, Africa and North America. In addition, in the case of proposed indicators, we analyzed the availability and accessibility of the data to compile such indicators.

T02-P14 - Participatory model for forest restoration areas prioritization

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The Nature Conservancy (TNC) elaborated Strategic Regional Restoration Plans (PERF – acronym in Portuguese) in order to evaluate and incentivize the forest restoration chain in different regions of the country. First, a diagnosis of regional stakeholders and forest restoration demand took place and allow the TNC team to prioritize areas for recovering actions. This exercise permits to optimize the use of resources on restoration projects and chain development. The participatory methodology was applied by TNC in 9 municipalities of Alto Juruena and Alto Teles Pires river basins in Mato Grosso State, where were defined in workshops variables like: indicators, evaluation criteria, layers, weights and classes per environmental and social priorities of these regions. Regional actors also pointed out indicators to identify the most important river margins (APP –in Portuguese) for restoration considering social and environmental relevance, they considered allocation; water supply needs; level of environmental conservation; erosion susceptibility; size and allocation of natural remnants; types of restoration techniques; distance of seedlings' nurseries; embargos; presence of hydropower plants. A ranking of areas was generated based on stakeholders' grades for restoration areas' importance. This ranking process aimed to call the attention of stakeholders on the importance of those areas for conservation purposes. After that maps of priority areas for restoration (including the 9 municipalities) were developed. The total amount of degraded APP identified was 15.434,15 ha from which: 1.283,29 ha were considered as low relevance; 4.936,06 ha medium relevance and 9214,80 ha as high relevance for restoration.

T02-P15 - The creation of a restoration matrix to facilitate flood recovery: The Colorado Water Conservation Board River Restoration Matrix

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To assist with recovery from the 2013 Front Range flood events, the Colorado Water Conservation Board provided funding to create a searchable revegetation database to facilitate the use of native plant species for river restoration. The resulting database includes 264 of Colorado's native riverine and wetland plant species into a searchable matrix that incorporates 50-plus parameters including nomenclature, county, hydrology, biophysiography, morphology, seed weight, seed storability, propagules type, germination protocol, and root attribute to allow better integration into bioengineering practices. The included woody, forb,

and graminoid species were largely based on prioritized feedback to the Southern Rockies Seed Network from over 200 Federal and State agencies, academia, municipalities, non-profits, and other interested parties. The talk will include a brief tutorial to demonstrate database integration for flood revegetation planning and implementation.

T02-P16 - The good, the bad, and the ugly of creating and implementing a short time-frame plant materials program for Colorado flood recovery

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The 2013 Front Range flooding occurred between September 9 to September 15, 2013 when a slow-moving cold front stalled over Colorado. The resulting heavy rain caused catastrophic damage over an approximately 200 miles (320 km) range, affecting a total of 17 counties. The Colorado Emergency Watershed Protection (EWP) Program was created to provide funding to implement emergency recovery measures to address hazards to life and property for the flood affected areas. Phase 2 of the program is funded and administered by the USDA Natural Resources Conservation Service (NRCS) and managed by the Colorado Water Conservation Board (CWCB) on behalf of the State, with total resources of \$63.2 million and a project time-period from Spring 2016 to Spring 2018.

To provide the necessary plant materials for revegetation, a portion of this funding is being used to create an ecotypic plant materials program. This talk will discuss the specifics of creating a technically sound program on a such short time-period, focusing on successes, challenges, and necessary compromises to meet the needs of approximately 134 recovery projects over a two-year period. Propagule collection and increase, as well as the storage, provision, and implementation of seed, containerized stock, and cuttings will be discussed in detail.

T02-P17 - Development of application for aid in the decision on the revegetation of degraded areas in the Cerrado biome

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Apps are infrequently used for environmental management, even though there are free platforms for app development. One limitation may be the necessity of collecting concrete data to create databases that are truly relevant for environmental management and conservation. Brazil harbors the greatest biodiversity in the world, and one of its ecosystems that is constantly threatened by land conversion and degradation is the Cerrado. Because of low tree density in some parts of the Cerrado, this biome is constantly targeted for agriculture and livestock, particularly in the state of Mato Grosso do Sul. This work aimed to develop an app to assist in the choice of interventions to restore degraded areas in the Cerrado. The app is based on a decision-making key for recovering degraded areas in the state of São Paulo. It includes questions about the area under consideration, recommended actions, information about the Cerrado biome and images, descriptions, and lists of common species in different Cerrado ecosystems. The app was developed on the MIT App Inventor platform from Android, which provides the development of free applications. Since it does not support large amounts of data, however, it was not possible to test the final stage in mobile devices and it is also not available on the platforms. Thus, the application was integrated with a WIX site. WIX is a platform of free and easy-to-use sites that offer additional plans that were needed to develop this work.

T02-P18 - A mathematical contribution to the Project Prioritization Protocol (PPP): Using Data Envelopment Analysis (DEA) to allocate conservation resources

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The biodiversity crisis has been facing limited conservation resources. Prioritising actions has always been an approach amongst decision-makers, such as government, NGOs, politicians and managers; including for conservation. Its importance and the necessity to have systematic models to support the decisions have been increasingly recognised by scientists. Joseph et. al have developed a protocol based on cost-effectiveness. Their ranking for species conservation relies on multiplying three output factors (biodiversity benefits, probability of success, and taxonomic distinctiveness) and dividing them by the action cost (input). However, there is a mathematical source of distortion that we aim to eliminate using the existent Data Envelopment Analysis (DEA) model. Our comparative analysis of PPP and DEA-PPP indicate different priority lists. When using the PPP, the importance of a factor (e.g. taxonomic distinctiveness) with a high value is neglected because another one (e.g. biodiversity benefit) has a low value. On the DEA-PPP, no variable can drag the importance of the others down. The weight of each factor in the relationship outputs-input is flexible for each species, allowing each of them to say why it needs to be prioritised for conservation. The species that have the higher combinations of outputs-input are the higher priorities, and establish the 100% priority border. The priority level of the others depends on the distance to this frontier, and the DEA cross-efficiency method refined the priority list. Our work has clearly demonstrated that the DEA method eliminates the ranking distortion of the original PPP, optimising the outcomes of conservation actions.

T02-P19 - Identification of priority areas for passive restoration in the Aruaí River Basin, Moju, Pará, Brazil

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The Aruaí River basin (BHRA), located in the municipality of Moju, state of Pará, Brazil, presents major changes in the landscape, caused by the expansion of palm oil plantations and other land use, which are responsible for most of deforestation and land degradation. As restoration is among the most expensive conservation strategies, developing approaches that help in the prioritization of areas for passive restoration efforts is a critical task. In this study, we used a multicriterial decision analysis framework in Geographic Information System (GIS) for identifying potential areas for passive restoration initiatives based in natural regeneration taking into account four criteria: natural vulnerability to erosion; land cover and land use use, proximity to primary forests and distance to roads. The results showed that 46.05% of the Aruaí basin has high potential of natural regeneration as an exclusive recovery method. The multicriterial analysis allowed us not only to identify priority areas for passive restoration but also to analyze how different environmental conditions and land use types may affect the selection of areas for restoration.

T02-P20 - Environmental suitability of Barra Seca Watershed and Doce River Mouth through the integration of environmental agendas

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From the identification of a critical condition of water scarcity in a territory located in Doce River Watershed, Brazil, this project was conceived, aiming to create the conditions to increase the water security in the region. Through an institutional arrangement it is possible to consolidate a new model of leverage of resources based on the vocation, capacity and interest of different partner institutions. Consequently, the results are more consistent, the economical resources are optimized and the scale of ecological restoration increases. Thus, this work presents an initiative developed in the Hydrographic Region of Barra Seca, in the state of Espírito Santo. This arrange formed by the private sector, NGOs, State government and the watershed committee aim to restore (i) 150 hectares of native forests, (ii) enhance sustainable production systems and (iii) guarantee water security through the integration of environmental initiatives underway in the Doce River region. Within this project, priority areas were

identified, defined jointly with the watershed committee. 51 farmers will benefit from ecological restoration, Rural Environmental Cadastre (CAR), and payments for environmental services (PES). In addition, this institutional arrangement designs benefits related to rural sanitation and environmental adequacy of the rural property. Consequently the arrangement will generate a gain in the region's water availability, which will allow an indirect impact on other rural properties, as well as on the municipal water supply systems.

T02-P21 - Restoration needs in Mesopotamia: Integrating ecosystems and wildlife species as conservation units.

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In Northeastern Argentina, the Mesopotamia region (20 Mha) harbours the country's highest biodiversity due to the occurrence of several ecosystems from temperate grasslands (Pampas) to subtropical forests, including wetlands, open forests and riparian environments. The region has also political relevance: it shares boundaries with Brazil, Paraguay and Uruguay. Major degradation drivers (proximate causes) are agro-industrial activities which increased the rate of biodiversity loss over the recent decades. The aim of this study was to determine the restoration needs, focused on ecosystems and species, to provide scientific and technical results for decision makers. Based on GIS analyses and field validations, maps of land use/land cover (LULC) were estimated. Maps of current distribution of 302 terrestrial threatened vertebrates were determined by means of extensive database review (including circa 20,000 records from participatory monitoring), expert consultations, and habitat evaluation. Using multi-criteria models we established five categories of degradation and conservation values. Major results indicated that: (1) areas with high restoration needs at the ecosystem level have low overlapping (5.5% of the whole study area: 1,086,029 ha) with zones with high conservation values (wildlife level), (2) such overlapping zones occur all over Mesopotamia without a clear landscape pattern, however (3) land uses most associated with them are exotic tree plantations, shrub crops, and mixed agricultural uses, likely because such activities provide more wildlife habitat than croplands and cattle raising. This particularly affects grassland birds. We discuss these results in the context of the "better practices" guidelines recently developed for the agricultural sector.

T02-P22 - Spatial prioritization in Atlantic Forest: Firsts steps to an aquatic ecosystem services approach

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Tropical deforestation has been linked to extreme floods, extreme droughts and water pollution, since forests can perform eco-hydrological functions, such as regulation of water flow and maintenance of water quality. In this context, forest restoration has emerged as one of the most promising approaches to reverse the process of forest degradation and the loss of water resources. In Brazil, the Atlantic Forest is composed of small and isolated fragments that represent only 12% of its original size, and present a limited capacity to provide and sustain essential ecosystem services. In order to guide policymaker decisions, it is necessary to establish priority areas of forest restoration. As spatial prioritization approaches are commonly based on biodiversity conservation, it is necessary to know to what extent this approach can be useful in aquatic ecosystem services conservation. Here we compare a spatial prioritization map of the Atlantic Forest based on biodiversity conservation (developed by International Institute for Sustainability in partnership with the Brazilian Ministry for the Environment) to the freshwater balance estimated by Brazilian National Agency of Water, for the year of 2015. We aimed to map and investigate potential synergies between these approaches, in order to guide us in the next steps on freshwater conservation. Few areas of critical state of water quantity and quality could be protected by biodiversity-based conservation, though. Our results suggest that more efforts are necessary to establish priority areas of forest restoration based on aquatic ecosystem services conservation.

T02-P23 - Ecological restoration in a burned nature sanctuary of Central Chile

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Forest fires are one of the main causes of degradation and loss of ecosystems in Central Chile. The vegetation of this area is characterized by its high biodiversity, high degree of endemism and critical condition of conservation, for which this area is in urgent need of restoration. The Nature Sanctuary Quebrada de la Plata suffered a fire in November of 2016, which affected 79% of its area. The objective of this work was to create an ecological restoration plan in a burned dryland forest in Nature Sanctuary in Central Chile. Homogeneous territorial units (HTU) were defined considering vegetation, aspect, fire severity and slope. This information and pre- and post-fire normalized vegetation difference index (NDVI) was estimated from satellite images. The information of the HTU was validated in the field. As a result, we defined priority areas for erosion control, revegetation and unburned areas, which could act as nuclei or sources of propagules. Ecological Restoration actions were proposed in priority areas. This project is proposed as a case study for research, teaching and community awareness on restoration for the conservation of biodiversity. It is also an interdisciplinary and interinstitutional experience that can serve as a reference for post-fire restoration in central Chile.

T02-P24 - Analysis and landscape planning for creation of an ecological corridor between forest reserves of the Atlantic Forest, BA, Brazil

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Forest fragmentation affects the biodiversity and may lead species local extinction. Restoring the connectivity between fragments through biodiversity corridors can favor the flow of fauna and flora. There are several models for drawing up designs of biodiversity corridors. The Circuitscape, Corridor Designer and LORACS (Landscape Organization and Connectivity Survey) were used to simulate the connection between the Pau Brasil National Park in Porto Seguro, Bahia, Brazil (47.016 ac) and the RPPN Veracel Station, in Santa Cruz Cabralia, Bahia, Brazil (14.996 ac) considering three species with extensive living areas: the Jaguaritica (*Felis pardalis*), the Mutum do sudeste (*Crax blumembachii*) and the Bugio (*Alouatta guariba*). The simulated ecological corridor covers a 1.329 ac of total area and 7 mi in length, where 60% of the area is being used for cacao production in a cabruca system (shaded by large native trees). Another 19% of the area is covered with forest in different stages of regeneration, 12% in pasture, 7% in rivers and lakes and 1% in eucalyptus forestry. Thus, the only intervention for the establishment of the corridor must be done in the pasture area. It is recommended the adoption of rational management of pasture with the planting of trees in order to increase the permeability of this matrix to favor the structural and functional connectivity between the protected areas. Although the conservation units are very close, the BR-367 highway crosses part of the proposed corridor and will require specific strategy for the fauna passages.

T02-P25 - Ecological restoration for protected areas: Setting priorities

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Ecological restoration is one of the main management actions for protected areas, essential for the conservation of biodiversity and the ecological functions of ecosystems. The state of São Paulo has one of the most diverse complex of ecosystems in Brazil, where the atlantic forest covers the coastal islands, crosses the mountain ranges and it is confined to the savannas in the interior of the state, between rivers that cross great extensions and permeate fragile areas like floodplains and mangroves. The Fundação Florestal, a government institution, manages 94 protected areas throughout the state and the diversity of envi-

ronments in these nearly 40,000 km², which are highly threatened by habitat fragmentation and degradation, requires different strategies and levels of intervention for restoration actions to be effective and sustainable. In this regard, we have developed an institutional program with guidelines, techniques, goals and procedures for the planning and execution of ecological restoration actions in protected areas. By identifying the main impacts and threats to ecosystems and human well-being, we set criteria for prioritizing areas for restoration as a way to rationalize available resources and avoid further damage to natural heritage. The main criteria of prioritization are: Risk to human life, riparian zone and springs in public water supply sources, under threatened or underrepresented vegetation formations (savannah, mangrove, restinga, paludal forest and altitude fields), connectivity and forest area by county. The challenge now is to create an equivalence method for degraded areas, leveling factors like cost and size, making the most of restoration opportunities.

T02-P26 - Modeling indicators, in landscape scale, to define strategic areas for restoration of ecosystems, a case study in São João River Basin, RJ, Brazil

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The present work proposes a Decision-making model to indicate favorable areas for the restoration of ecosystems, considering variables that characterize the fragmentation mosaic and the topological relationships as isolation degree, proximity to each other and with other types of vegetation cover or land use. These variables were used in the construction of two indicators: connectivity potential (the potentiality of a given area in forming ecological corridors) and regeneration potential (the potentiality of a given area for natural regeneration). The association between these variables will serve to indicate areas that have the best cost benefit in terms of restoration, as well as being more successful in ecological terms. The indicators were modeled using geoprocessing techniques and a weighting method, where the weights and grades were assigned by specialists from different institutions, that works on the subject. As a case study, the São João River Basin, located in the Center-North region of Rio de Janeiro State, was selected for its importance in the protection and conservation of water resources and preservation of Atlantic forest remnants, which is considered one of the world's hotspots. The results showed that, considering the variables used in the construction of the indicators, about 60% of the area have a moderate connectivity potential, favored mainly by the presence of a conservation unit; and about 40% and 39% of the area have a low and moderate regeneration potential, respectively.

Seeds and seedling production

T14-P01 - Implantation a provisional nursery to supply of regional native seedlings

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Restoring a segment of the landscape depends upon the availability of seedlings or seeds of plants species native of the region to be restored. In a region of Rain Forest, transition to Seasonal Semideciduous Forest, in Santana de Parnaíba (State of São Paulo), after a floristic survey, we concluded that few native species could be found in nurseries. That led to the establishment of a temporary nursery for supplying a restoration project for 5 years, therefore avoiding the introduction of regional exotic species. To reduce the cost of seedlings, the nursery produced bag seedlings in a simple structure. In 5 years, this nursery produced more than 150 thousands seedlings, of 147 native species out of 173 species detected in the floristic survey, at cost of US \$ 0.60 per seedling. To collect seeds, trails within native forest around were inspected monthly. Matrices were marked and data on the phenology of each species was gathered. The processing and treatment of the seeds were executed in the nursery. Out of the 26 identified species that did not produce seedlings, seeds were not found for seven species, throughout the five years of collection. Few parental plants were found for 10 species which produce small quantities of seeds or seedlings. Seed germination below 1% was detected for 9 plant species, not producing satisfactory amount of seedlings. This approach allowed the success of the local restoration, maintaining the species that occur in the reference ecosystems.

T14-P02 - The effect of biochar on Atlantic Forest seedlings: Environmental and socio-economic analysis

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The Atlantic Forest used to cover vast areas of the Eastern coast of Brazil but it suffered serious deforestation. Despite having lost approximately 90% of its vegetation it still provides habitat to thousands of endemic species and contributes to provision of crucial ecosystem services to Brazilian population. Over the last years, restoration has been promoted to recover habitat and ecosystem services. One of the bottlenecks of restoration is seedlings production due to high costs and low survival. To this end, this research evaluated the effect of biochar on the performance of Atlantic Forest seedlings used for restoration. Biochar is a product obtained from pyrolysis of organic residues that has shown potential as soil enhancer and for greenhouse gases sequestration. Biochar use in restoration is relatively new. In our study, we used biochar derived from *Gliricidia sepium* that was abundant locally. We chose four species: Aroeira Pimenteira, Grandiuva, Jequitiba Rose and Pau Cigarra and we worked with four treatments (30 replicates each): control, 20% biochar, 40% biochar and limestone. The height and diameter of the seedlings were measured monthly and we analysed the results using two-way ANOVA. Aroeira Pimenteira and Jequitiba Rose, showed better performance for the treatment limestone ($p < 0.005$). However, Pau Cigarra and Grandiuva responded better in the presence of biochar. We will also show the results of cost-benefit analysis of biochar and other substrates used by the small nurseries owners and the social acceptance of biochar as a potential alternative in seedlings production (based on focus groups).

T14-P03 - Rapid evolution of plant materials propagated for restoration.

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The growing number of restoration projects worldwide leads to increasing demand for seeds of native species. The seeds are collected in the wild and are then often used as sources for large-scale cultivation on specialized farms. Farm-propagated seeds are then used for restoration projects. However, during cultivation plants face novel environmental conditions compared to those in natural populations, and there is a considerable danger that plants in cultivation are subject to unintended selection and

consequently lose the adaptation to their natural habitats. Although the propagation methods are usually designed to maintain as much natural genetic diversity as possible, the effectivity of these measures was never properly tested. We obtained seeds of five species and several consecutive cultivation generations from one of the largest native seed producing company in Germany. We used molecular markers (AFLP) and a common garden experiment to test for genetic and phenotypic changes of these plants during cultivation. The molecular markers detected evolutionary changes in three out of five species, while phenotypic changes were apparent in two species. The changes were mostly minor. The only species that showed substantial genetic and phenotypic changes was a predominantly selfing species. Synthesis and application Agricultural propagation of native seed material for restoration causes unintended selection, at least in some species. The effects are mostly mild, but attention is necessary in predominantly selfing species, where the evolutionary changes may happen faster and effects may be more severe.

T14-P04 - Use of biosolid in the composition of substrate for *Schinus molle*, *Licania tomentosa* and *Peltophorum dubium* seedlings production

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The use of urban sewage sludge in agriculture as a source of organic matter has been shown as a sustainable alternative for final disposal of this residue. After treatment and stabilization sewage sludge is known as biosolid and can offer organic matter and nutrients for plants growth. This study aimed to evaluate the feasibility of biosolid usage as a substrate component for *Schinus molle* L, *Licania tomentosa* (Benth) Fritsch. e *Peltophorum dubium* (Springer.) seedlings production. The experimental design was completely randomized with four treatments and six repetitions: three different proportions of biosolid in the mixture (25, 50 e 100%) compared to one commonly used substrate containing 50% of cattle manure as control, all treatments were associated with sand and subsoil. The study was conducted in the Universidade Federal Rural do Rio de Janeiro campus, Seropédica. Firstly, the seedlings were produced in 280 cm³ tubes and 120 days after sowing they were transplanted to 18L vases. To evaluate the development of the seedlings the plant height and stem diameter were determined by the time of transplantation and every two months during the following eight months. Substrate with 50% of cattle manure favored the development of *Schinus molle* seedlings when compared to different biosolid substrates. However, for *Licania tomentosa* and *Peltophorum dubium* the substrates containing biosolid presented the best results of seedling growth. The results demonstrate that biosolid may be considered suitable for the development of these species and its usage as seedlings substrate is a feasible alternative for final disposal.

T14-P05 - Isolation and characterization of PGPR from the rhizosphere of *Leymus chinensis* of China

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Finding microbe strain resource in grassland is the key foundation stone for agricultural industry and ecological restoration. Plant growth promotion rhizobacteria (PGPR) are characterized as root-colonizing bacteria that exert plant growth promotion directly or biocontrol effects indirectly. In present study, the PGPR strains were isolated and identified from *Leymus chinensis* based on the measurement of nitrogen fixation, phosphate solubilization and IAA production capacities, and the effects of potential PGPR on seedling growth of *Leymus chinensis* were also studied. Our results suggest that there are abundant PGPR resources in the rhizosphere of *Leymus chinensis* cultivated in Songnen plain, Hulunbuir and Inner Mongolia grassland of China. A set of 120 strains was isolated, 83 of them have ability of dissolving inorganic phosphorus and the amount of dissolving phosphorus in 2.7~93.4#956;g/ml; 22 of them have both ability of dissolving inorganic phosphorus and producing IAA and the amount of IAA in 3.01~30.43#956;g/ml; only 1 strain showed all three PGP traits. On the basis of multiple PGP traits, ten isolates were selected to test their potential as PGPR on *Leymus chinensis* seedling. Three of them have the ability of promoting the growth of *Leymus chinensis* seedling and they belong to *Phyllobacterium* genus, *Pantoea* genus and *Inqulinus ginsengisoli* respectively. Our results highlight that the application of PGPR can improve plant growth, decrease the use of fertilizers and reduce the cost of ecological restoration.

T14-P06 - In situ conservation of forest species: A proposal for selection of seed trees for ecological restoration

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The Atlantic Forest is an endangered eco-region located on the eastern side of South America, covers Brazil, Argentina, Paraguay and a small part of Uruguay. The initiatives for conservation and sustainable management of genetic resources can help maintain the ecosystem services it provides. The objective of this project was to generate information for selection and management of seedlings to be used in the recovery of degraded areas. From December 2016 to January 2017, in the Mbaracayú Forest Natural Reserve, tree species of economic and environmental importance were selected. A total of 132 trees belonging to 24 species were characterized, identified and recorded. Physical and phenological characteristics have been monitored every 30 days, and mature fruits are collected from each tree. The seeds are processed, characterized and stored in a conservation chamber. Plants are produced in nursery to determine their quality and relate them to seedlings. Seeds of *Handroanthus heptaphyllus*, *Astronium fraxinifolium*, *Myrcianthes pungens*, *Schefflera morototoni*, *Pouteria* sp., *Campomanesia xanthocarpa*, *Cordia trichotoma* and *Ilex paraguariensis* were harvested. The species *Myrcianthes pungens* and *Pouteria* sp. presented 45 and 70% of germination, respectively, and are currently grown in the nursery and have productive potential. The selection and monitoring of seedlings in their natural habitat may help with the provision of high quality genetic material and conservation of species of ecological relevance in their centers of origin.

T14-P07 - Initial development of *Maytenus ilicifolia* and *Bauhinia forficata* seedlings produced with different substrate

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The use of species with medicinal potential is well known throughout history, since they have always been used and marketed, in natura form, as medicinal teas, and mainly for the low cost of acquisition. The commercialization of these plants often consists in the diversification of the income of small farms. Considering the importance of the use of native medicinal species, the present study aims to evaluate the initial behavior, survival and mortality of *Maytenus ilicifolia* and *Bauhinia forficata* seedlings produced with different substrates. The study area is located in the central region of Rio Grande do Sul. In the production of seedlings, different proportions of bovine vermicompost (20, 40, 50, 60 and 80%) and non-sterile soil were tested for both species. Treatments with the isolates of *Trichoderma* sp.: Tricho 1, Tricho 2, Tricho 13, Tricho 33, Tricho control and Tricho 10 both treatments. Planting was done in November 2016, the variables collected were: survival, mortality, height (H), diameter at soil height (DAS). These data were collected at planting and 30 days after planting. The survival rate was 100% and 99.09% for *Maytenus* and *Bauhinia*, respectively. The development of *Maytenus ilicifolia* was highlighted with the substrate of 50% vermicompost and 50% soil, for *Trichoderma* sp. Tricho 10 presented better performance. For the Cow Paw the composition of 80% vermicompost and 20% soil was the best development, the isolates of Tricho 1 and Tricho 33 were highlighted, serving this study as a base for the production of seedlings with ecological inputs.

T14-P08 - Restoration of eurosiberian silvosteppe vegetation with *Quercus* sp in Fortress Hill Lempes – Harman marsh Romania

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This research is a part of a LIFE Natura project, “The forest and eutrophic marshes from Prejmer” and “Fortress-hill Lempes – Harman marsh”, funded by the European Commission. The project aimed to enhance/improve the conservation status and to support the natural processes in both Natura 2000 sites. Due to abundant fructification in 2012, acorns collected from 68 marked oaks were used for multiplication. Further, seeds were biochemically tested using tetrazolium, for obtaining germinative capacity, a 1000 seeds weight, number of seeds per kg, number of germinated seeds per kg. Acorns were deposited in barrels filled with water at 5 Celsius degrees, water being changed weekly during one month. Seeds were planted in pots in a mixture of soil and sand, thus obtaining 7000 seedlings which were transplanted in the greenhouse. In the spring of 2015, seedlings obtained in the greenhouse were planted in the field. In parallel, starting September 2014, the natural regeneration of oak was assisted by supportive actions (elimination of redundant vegetation nearby) in 3,4 ha; On Lempes Hill - Harman, actions for eliminating the attack of *Microsphaera abbreviata* pathogenic, using TILD fungicide of 0,03% concentration were taken. Survival percentage in natural conditions of the seedlings was approximately 70% in the first year. As a result of completion and protection measures with both repellent substances and electric fencing, after three years, rate of success was approximately 90%. An area of 3.4 ha of community interest habitat were restored in Fortress-Hill Lempes, thus facilitating long term conservation.

T14-P09 - Can inoculation of symbiotic microorganisms reduce the need for fertilizers in the production of Atlantic Forest species seedlings?

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Seedling production with inoculation of two types of microorganisms was tested at AES-Tietê Forest Nursery in Promissão-SP as an alternative for the arboreal Atlantic Forest species growth. Noduliferous nitrogen-fixing bacteria (NNFB) and Vesicular-arbuscular mycorrhizal fungi (VAMF) were inoculated in leguminous and VAMF in non-leguminous species. The 100% reference is the usual amount of fertilizer used in the nursery. Nine species were used in four different treatments in the first experiment: (1) without VAMF inoculation and 100% fertilization for N, P, K; (2) VAMF inoculation and 100% fertilization for N, P, K; (3) VAMF inoculation, 1/3 fertilization for P and 100% for N and K; (4) VAMF inoculation and non-fertilization. The VAMF inoculation with reduction of P dose (T3) resulted in equal or superior growth in comparison with other treatments in the nine species. In the second experiment was selected four noduliferous leguminous species. Selected strains produced by EMBRAPA Agrobiologia were used in the following treatments: (1) without NNFB and usual fertilization; (2) NNFB and usual fertilization; (3) NNBF, 1/3 fertilization for N and usual for P and K; (4) BBNF, usual fertilization for P and K and N omission; (5) NNBF and VAMF, usual fertilization for K and 1/3 for N and P; (6) NNBF and VAMF and non-fertilization. The species showed different responses to the NNBF inoculation, being positive for one species, negative for other and indifferent for two of them. The reduction of fertilizer application in seedling production was not an advantage for any of the tested species.

T14-P10 - Growth of seedlings from Atlantic Forest species using biosolids as substrate

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Considering that planting seedlings is the most used technique for forest restoration in Brazil, their production is an important part of the restoration chain. The solid waste of sewage treatment, called biosolids, has been showing a great potential to be used as an alternative of substrate for seedling production. The objective of this study was to evaluate the growth of two Atlantic Forest species in commercial substrates and in biosolids. Four treatments were evaluated, being them: (T1) commercial substrate based on Sphagnum peat moss; (T2) commercial substrate based on composed Pinus bark; (T3) biosolid dried in the open air; (T4) biosolid thermally dried. The commercial substrates were bought locally and the biosolids were provided by the Rio de Janeiro state water and sewage company (CEDAE). The evaluated species were *Peltophorum dubium* (pioneer) and *Colubrina granulosa* (non-pioneer), from which shoot height was measured when seedlings were at five months old. The average height verified for the seedlings of *Peltophorum dubium* in the different treatments was: (T1) 11.82cm; (T2) 14.36cm; (T3) 39.61cm; And (T4) 37.28cm and for *Colubrina granulosa*: (T1) 10.86cm; (T2) 7.38cm; (T3) 30.61cm; And (T4) 34.92cm. It was observed for both species that in average the biosolids obtained three times higher growth than the commercial substrates. No differences were observed between the two commercial substrates nor between the two biosolids. It is possible to conclude that the growth in height of both species was higher when the biosolid was used rather than the commercial substrates.

T14-P11 - The International Network for Seed-based Restoration (INSR)

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The International Network for Seed-based Restoration (INSR, ser-insr.org), a new Section of the Society for Ecological Restoration, seeks to raise the profile of seed-based needs for ecosystem restoration. Ecological restoration is a growing sector with costs exceeding a trillion dollars annually and seed collection and cultivation industries as important components. Thus the need to develop standards for native plant seed collection, production, testing, regulation and use is critical. INSR members include professionals, scientists, students, and representatives of industry, government and non-governmental organizations. Major goals are to; 1) advance public education, policy, and awareness of the global need for native plant seed research, conservation and use; 2) sponsor a forum for interchange of new ideas, approaches, data developed, and lessons learned relevant to planning, policy and science regarding native seed ecology technology and restoration; 3) foster collaboration to develop standards for native plant seed testing and regulation; and 4) serve as an emergency expert panel to address germplasm, biodiversity, conservation, seed farming and restoration issues. To accomplish these goals, INSR will sponsor conferences, workshops, field trips, webinars and forum discussions. In time we hope to provide funds to improve seed science and use in emerging economies by providing student scholarships and international grants.

T14-P12 - Growth of two tropical species seedlings due to base fertilization

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The knowledge of the proper procedures to produce quality seedlings of native species, provides more efficiency in the implementation of restoration projects, and reduction of production costs. The base fertilization, performed in the substrate preparation, provides the plants with the necessary nutrients for their initial development during the production cycle, and maintenance applications are recommended. The most widely used fertilizers consist of NPK fast-release formulations and controlled release capsule-bound products that regulate the release of nutrients to the plant. The objective was to evaluate the growth of *Platygodium elegans* and *Guarea guidonia* seedlings under the influence of three forms of base fertilization, without addition of fertilizer, with soluble fertilizer and with controlled release fertilizer, produced in nursery with use of tree pots. At 254 days after

sowing, the height and diameter of the seedlings were evaluated. In general, the seedlings produced with controlled release fertilization showed a greater overall growth. The fertilizer's property in promoting a more distributed nutrient release throughout the cycle, allows better absorption by the plants and reduces losses by leaching and volatilization. Reducing or eliminating cover fertilizer reduces labor and fertilizer costs, reducing production costs. We suggest the use of controlled release fertilizer to produce seedlings in tree pots.

T14-P13 - Inoculation efficiency of rhizobia and vesicular arbuscular mycorrhizal in *Parapiptadenia rigida* seedlings in nursery conditions

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The symbiotic relationship between soil bacteria and fungi with legumes trees may provide ecological and economic benefits in the recovery of degraded areas. This experiment evaluated the inoculation efficiency of both rhizobia and mycorrhizal fungal strains in seedlings of *Parapiptadenia rigida*, a fast growing legume tree, widely used in restoration projects in the Brazilian Atlantic Forest. The rhizobia strains were BR 9004 (*Bradyrhizobium elkanii*), BR 3804 (*Mesorhizobium plurifarum*) and BR 827 (*Ensifer fredii*). A mix of seven fungal species was used for mycorrhizae. A completely randomized 3 (rhizobia inoculants) x 2 (with and without mycorrhizas) factorial design was used, with three controls (nitrogen, mycorrhizal and absolute), and 5 replicates. Nutritional solution was supplied to all treatments, while the nitrogen control received 150 mg of N total. After 8 months, we measured height, diameter at the base of the stem, aboveground, root and dry nodules mass, and the mycorrhizal colonization. The treatments showed a significant effect ($p < 0.05$) for all variables, except for the dry mass of nodules. The seedlings submitted to nitrogen fertilization had the highest growing. The rhizobium strain with better performance was BR 827, which allowed the highest values of dry root mass and dry aboveground mass, respectively, 170% and 226% higher than the absolute control, even in the absence of mycorrhizal inoculation. The BR 3804 strain resulted in more developed seedlings only when inoculated with mycorrhizae. The strain BR 9004 did not differ statistically from the controls, suggesting lower effectiveness.

T14-P14 - Seed collection: How to organize?

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With the publication of Brazil's new forest law in 2012, large scale ecological restoration has become a great necessity for government, academic, business and non-governmental organizations circles. To meet the large scale quantity of seeds that this technique requires, collectors have created seed collector's networks in places like Mato Grosso and west of Bahia. With this new implement there were huge amounts of interesting information and data generated, however they were not easy to process and analyse. So a new management software (Baoba GCS), easy and practical to use, was developed. In it, it is possible to register each network, or community, by: name, technical manager, GPS location, address, etc. Additionally, insert each individual collector by name, personal data, gender, etc, creating a useful database of people and seed collecting places. The software also creates a database of local species classified by: popular and scientific names; seed quantity weight in kilograms; and price for each seed specie etc. This software allows information to be centralized and organized so that it is optimised for academic purposes, like statistical analysis; as well as for commercial uses, making it easier to buy and sell seeds, reducing losses, and putting collectors and buyers in touch. The software can virtually be used in any place worldwide that works with seed collectors. Coming soon, the software will be available online free of charges on Baoba Florestal's web site.

T14-P15 - Propagation of *Mostuea muricata*: An Atlantic Forest threatened shrub

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Mostuea muricata Sobral & Lc. Rossi is a shrub, with disjunct geographic distribution and occurrence in sandysoils of Cerradões understories. Little is known about the species and ecology studies are important to support its conservation since the species was just discovered and has already been classified as vulnerable. The aim of this work was to assess the biometric characteristics of its fruits and seeds and the effect of dormancy breaking treatments on seed germination. Measurements of length, width, thickness and fresh mass in 60 fruits and seeds collected in Anhembi - SP were carried out at ESALQ / USP's Laboratory of Plant Ecology and Agroecology. There was great variation in these measures and the mean values for length, width, thickness and fresh weigh were 7.60 mm, 7.38 mm, 3.88 mm, 0.170 g, respectively. The seeds were 4.69 mm long, 2.79 mm wide, 1.56 mm thick and 0.012 g mass. For the germination study the seeds received five treatments: i) H₂SO₄ 98% (30 seconds); ii) H₂SO₄ 98% (1 minute); iii) H₂SO₄ 98% (5 minutes); iv) mechanical scarification; v) control. The test was conducted in germinators with temperature of 25°C and constant photoperiod, with three replicates of 25 seeds. There was no germination only in the control treatment, with the scarification being the one with the highest germination rate (80%), followed by H₂SO₄ (5') (70%). Seeds of *M. muricata* presented waterproof tegument, mechanical scarification as sulfuric acid per 5 minutes were efficient methods to overcome dormancy.

T14-P16 - Second generation seed orchards of *Nothofagus obliqua* and *N. alpina*: generating genetic resources for ecological restoration.

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In spite of the ecological and biogeographical importance of the *Nothofagus* genus in the Southern Hemisphere's temperate forests, its habitat has been seriously degraded. Our objective was to establish a strategy for the conservation of the *Nothofagus obliqua* and *N. alpina* genetic resources for ecological restoration initiatives. In 1996, seeds were collected between 33° and 41° SL and a set of provenance and progeny trials (in the year 2000) were established with *Nothofagus obliqua* (roble) and *N. alpina* (raulí) seedlings produced from these germplasm. In the operative plan, we evaluate the phenotypic expression (productivity, volume, and shape) of the different progenies and provenances, after 14 years in a common environment, to clone the best individuals (BLUP) in order to i) form two second-generation seed orchards ii) and evaluate the survival rate of different provenances and progenies in different environments, especially in degraded forests. Here, we present the results of two trials of 630 and 1240 trees, respectively, all of which have been established in southern Chile (42°11'; 72° 2'). The average calculated annual diameter increment, based on 5% of the best individuals, was about 2 cm for roble and 1.5 cm for raulí. In both trials, the cumulative log productivity of the best individuals was three times that of randomly selected individuals. Also, second generation seed orchards of roble were established during the winter of 2016 and 2,400 plants were grafted with spikes of *N. alpina* from selected clones to establish a second generation seed orchard of raulí (2017). We promote these genetic resources for conservation purposes, and especially for ecological restoration initiatives.

T14-P17 - Richness of tree species in restoration projects in the Brazilian Federal District

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The Cerrado biome of Brazil houses over 12.000 species of vascular plants and it is the world richest savannah in plant species. The Brazilian Federal District - BFD is located in the Cerrado and local restoration projects have based on tree plantation due to its known catalytic effect on ecosystem recovery. However, these projects have not been driving communities to a desired

trajectory probably because of the limited plant diversity caused by a combination of low species richness and evenness in sites undergoing restoration. We investigated in this work the number of tree species available in local nurseries, recommended in restoration projects, and effectively present on sites under restoration. Sampling sufficiency was based on rarefaction curves, and results indicated that 481 Cerrado tree species distributed among 72 botanic families were involved in the local restoration business. Nurseries offered 242 species of 48 families, restoration projects recommended 366 species of 70 families, and sites under ecological restoration presented 249 species from 54 families. The numbers of species and botanic families recommended by restoration projects were the highest among the three surveyed sources followed by the species richness present on sites and finally the species richness available in local nurseries. These results indicate that many tree species listed in restoration projects were not planted and that some species found on sites under restoration come from nurseries outside BFD. Results also suggest that the limited number of species available in local nurseries is partially responsible for the low species richness on restoration sites.

T14-P18 - Nutritional and water conditioning during nursery production of *Beilschmiedia berteriana* plants: A species with high ecological value and in endangered condition in Central Chile

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Beilschmiedia berteriana (Gay) Kosterm is an endangered Chilean species declared as endangered by the IUCN (2001), but its restoration in Mediterranean environments is affected by the lack of nursery production protocols. Thus, our objective was to evaluate the effect of nitrogen and potassium fertilization on morpho-physiological performance of *B. berteriana* plants submitted to water restriction (WR) during hardening phase of nursery production. During rapid growth phase plants were fertilized with two nitrogen and potassium doses (100 and 300 mg L⁻¹). During hardening stage plants were divided in non-WR treatment with 50% of soil water content and WR cycles treatment. WR consisted in decreasing soil water content down to 25%, associated to Fv/Fm values lower than 0.55, and then rehydrate up to field capacity, performing this in a cyclic fashion. Total biomass was not affected by fertilization treatments nor WR. However, a decrease in root biomass was observed in WR plants ($p < 0.05$). Nitrogen and calcium contents in whole plant increased significantly with 300 mg L⁻¹ nitrogen fertilization ($p < 0.05$). Also, while this treatment decreased Fv/Fm values during WR 10 days before the 100 mg L⁻¹ treatment, recovery of Fv/Fm was rapidly achieved during rehydration (0.7). Finally, we conclude that an increase in nitrogen fertilization (300 mg L⁻¹) has a positive effect for recovery of photochemical efficiency values after a stress caused by WR treatments while potassium fertilization has not effect.

Soil aspects in restoration ecology

T08-P01 - Effects of restoration systems on water retention capacity of accumulated litter and soil moisture at two sites with contrasting soil properties

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Soil litter stock is considered very important to promote grass suppression, nutrient cycling and soil water retention on degraded sites under restoration. Litter composition, as well as its chemical and physical characteristics, depend directly on the site's floristic composition, water and temperature regimes. We investigated how contrasting soil properties and different forest restoration systems affect the soil litter's water retention capacity, as well as whether litter cover and litter water retention capacity would affect soil moisture. Sampling was carried out in two sites (Site 1: Red Ultisol, clay texture; Site 2: Alic Red-Yellow Ultisol, sandy texture), in two different forest restoration systems (high diversity (HD) and agroforestry system (AFS), 19 years after plantation. A total of 12 litter samples were collected in each system (n=48). Soil samples were collected on the same points again after five days of litter removal. Paired soil samples were collected under intact litter cover in both instances. Litter water retention capacity was estimated using the Blow Method and soil humidity was evaluated using the gravimetric method. There was no significant difference in the litter's water retention capacity between sites. However, litter in the HD system tended to have higher water retention capacity in both sites comparing to AFS. Litter cover had no effect on soil moisture, although soil moisture differed significantly between sites. We concluded that, no matter the importance of litter stock on ecosystem processes, soil intrinsic properties might have higher effect on soil moisture than litter cover.

T08-P02 - Biochar potential as a soil enhancer for forest restoration in areas degraded by gold mining in the Peruvian Amazon

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Despite being a relatively new topic, biochar (pyrolyzed organic matter aimed to be used as an amendment) is increasingly investigated as a potential alternative for increasing soil fertility while improving soil organic carbon sequestration. Indeed, biochar application in soils is known to reduce nutrients leaching, increase water retention, increase density and diversity of the soil biota, reduce greenhouse gas emissions from soil, increase soil pH, and, depending on the soil's conditions and the quality of the biochar, significantly increases plant aboveground productivity. Our project aims to produce quality biochar from sawdust and Brazil nut husks to tackle the soils' specific demands to degraded gold mining areas, then to use the scientific results on increased production and enhanced soil quality to evaluate the potential of biochar as a reforestation tool; and finally, to promote the use of sustainably produced biochar as a safe and biological amendment. To fulfill its objective, the project made the acquisition of a continuous, industrial scale, fifth of its kind worldwide pyrolyser able to process up to 100 kg of biomass per hour. The project also builds small-scale, robust, and cheap biochar ovens for locals and varied on-site biochar productions. For now, the pyrolyzing technologies have been put in place, tested and approved. Sawdust and nut husk biochars have been tested to comply with the International Biochar Initiative quality standards. Recently, 5.3 tons of biochar have been amended on a total of 8 ha, divided on three different treatments, to study plants and soil reaction.

T08-P03 - The impact of nutrient source, nutrient loading, and tidal restrictions on the accumulation of nitrogen in estuarine sediment and biota

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Nutrient enrichment can have detrimental effects on the form and function of estuarine systems. Restoration initiatives often include monitoring efforts that only assess nutrient concentrations in water quality samples. However, water quality data provides a temporary measure of the nutrient concentrations in water and the concentrations change as nitrogen is utilized by primary producers, fixed by microorganisms in sediment, and flushed with tidal water. In this study, we used stable nitrogen isotope analysis to investigate the influence of nutrient sources, nutrient loading, and tidal restrictions on the accumulation of nitrogen in estuarine sediment, plants, macroinvertebrates, fish, and algae in Elkhorn Slough, CA. Stable nitrogen isotope analysis of wetland sediment and biota was used to determine sources of nitrogen pollution as well as understand how much of the nitrogen remained within the estuary. Nutrient loading was determined using long-term water quality data from the Elkhorn Slough Estuarine Research Reserve (ESNERR). Finally, the influence of tidal restrictions on the accumulation of nitrogen in sediment and biota was considered using residence time. Our results suggest that nutrient source, nutrient loading, and hydrological restrictions may have a role in determining the impact and accumulation of nitrogen in estuarine systems. Our results highlight the importance of considering nutrient sources, nutrient loading, and tidal restrictions during the development and implementation of restoration efforts.

T08-P04 - Reforestation of gullies for ecological restoration purpose; Use of native tree species, organic mulching and polymer water retainer

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Soil erosion is a common degradation process, especially difficult to recover in case of gullies, where soil thickness decreases continuously. Restoration of these sites with native plants can potentially foster soil recovery. We assessed the effectiveness of planting native trees in a gully with different treatments of soil cover and addition of a commercial polymer water retainer, in order to restore a temperate forest cover in Michoacan, Mexico. A plantation trial with native tree species *Pinus devoniana*, *Pinus leiophylla* and *Fraxinus udhei* in a latin square design was carried out. We established 30 plots on bare ground, 30 with natural mulch (pine needles litter), 30 with an organic mulch, in 45 plots we applied agrogel in each seedling and 45 seedlings were used as control. Seedlings survival and growth were assessed during four years. Initial soil condition was analyzed for each plot (moisture, texture, apparent density, organic matter). After one year, *Pinus devoniana* presented the highest survival (81%), followed by *P. leiophylla* (68%) and *F. udhei* (44%). We found significant effects of cover treatment only for *F. udhei*. Survival was favored because it was a rainy year with a very short dry season, compared to historical climate. Survival rates for the next three years didn't decrease substantially and general survival was 56%. *P. devoniana* can be considered the best species for gullies revegetation because of the high survival rate and the large canopy that provide cover and protect the remnant soil.

T08-P05 - Changes in soil attributes of Cerrado wet grasslands (Veredas) due to the level of degradation

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Veredas are wet grasslands in the Cerrado (Brazilian savanna), characterized by peaty and shallow soils, with superficial sandy and subsuperficial clayey soils, high level of organic matter and elevated hydric saturation. They are ecosystems with low resilience and sensitive to disturbance. To verify if degradation changes soil properties in Veredas, we compared chemical attributes of the surface soil of six veredas in the state of Minas Gerais, in distinct levels of anthropization, as follows: low degradation (Água Doce (AD)), Almescla (AM)), intermediate degradation (São Francisco (SF), Pindaibal (PI)) and high level of degradation (Capivara (CA) and Buriti Grosso (BG)). Composed soil samples were collected from 0 to 20cm deep in each site. Soil attributes

were compared using GLM procedure of ANOVA and similarity between the six veredas through similarity dendrogram. Higher levels of Ca, Sb, t, T, V, and MO were recorded in the low degraded Veredas, followed by veredas in intermediate degradation stage that presented intermediate levels of Ca, Mg, C, Sb, V; and by the most degraded veredas, which presented high level of Ph, Al, H+Al and low levels of Ca, Mg, K, Sb and, V. It can be inferred that the veredas that suffered the greatest anthropic interventions showed a significant reduction in soil fertility. These results indicate that, ecological restoration of Veredas will require not only reintroduction of plants, but also the recovery of soil properties.

T08-P06 - Soil attributes changes after five years of an Agroforestry System implementation in an Ultisols area, Pindorama, Brasil

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Agroforestry systems (AFS) can contribute with ecological restoration and can promote the socioeconomic and ecological resilience of degraded soil areas. AFS was tested to recover some soil attributes of a Kandiuistalf soil after the control of a severe gully erosion, in Pindorama, Sao Paulo State, Brazil. The AFS adopted different management treatments: T1 (Mower coupled to a tractor; tree seedlings in planting holes spaced 3 x 2 m fertilized with 300 g of lime plus 200 g superphosphate); T2 (herbicide, tree seedlings in planting holes spaced 3.5 x 2 m fertilized with 2 t ha⁻¹ of lime, 2 t ha⁻¹ of filter cake from sugarcane mill, 300 kg of NPK 8-28-16, maize cultivated between tree lines); T3 (Plough, harrow, trencher, tree seedlings planted in furrows spaced 3.5 x 2 m fertilized with 2 t ha⁻¹ of lime and filter cake, 300 kg of NPK 8-28-16, maize cropped between tree lines). Soil chemical attributes were quantified and statistically evaluated by ANOVA and Duncan's test (both at $p < 0.05$) considering the measurements made in 2011 and 2016. A forest remnant nearby the studied area sampled and used as reference. After only five years of AFS, all three treatments increased the soil organic matter also resulting in higher levels of soil phosphorus, cation exchange capacity, sum of bases, exchangeable calcium and magnesium. It is clear that soil preparation allied to fertilization prior to AFS were important by creating favourable conditions to the establishment and growing of vegetation in degraded soil areas.

T08-P07 - Soil respiration in Atlantic Forest restoration sites and forest fragments

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Belowground respiration processes, also referred as soil respiration, release most of the carbon captured by plant photosynthesis, and soil CO₂ efflux is the way in most of this carbon returns to atmosphere. Soil respiration is the result of joint activity of plant roots, plant symbiotic partners and organic matter consumers, and thus is dependent on vegetation (photosynthetic rate, root density, litter quality), microclimate (temperature and humidity) and soil aeration. Therefore, CO₂ efflux is a good indicator of ecosystem metabolism and it can indicate recover of ecosystem functions in restoration sites, such as productivity, decomposition and nutrient cycling. We aimed to estimate CO₂ efflux, as a proxy for total soil respiration, in four Atlantic Forest restoration sites (~10 years old reforestations) and two forest fragments located at northern Paraná state, Brazil, in order to investigate the level of recovery of both root-associated and decomposer respiration, compared to the levels in reference forests. Soil respiration rate was 1.2 higher times at forest fragments, while soil temperature and humidity were higher at reforestation sites. Root-related respiration contributed with 1% at reforested areas and 6% to total CO₂ at the fragments. Other studies held at the same area also showed that the restoration sites showed equivalent or even higher stocks of both biomass and necromass, when compared to forest fragments. Thus, we concluded that ecosystem metabolism is recovering fast in restoration sites, with soil CO₂ efflux following the quick increase in carbon stocks.

T08-P08 - The effects of warming and nitrogen deposition on soil carbon and nitrogen processes in vegetation restored meadow of Wugong Mountain, China

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The meadow of Wugong Mountain in Jiangxi province, southern China, has the characteristics of large area and low elevation baseline distribution, it is an important indicator vegetation of climate change. However, excessive tourism development and human disturbance caused serious degradation of the mountain meadow. We want to research the effects of the meadow soil CO₂ and N₂O emission rate when the rise of temperature and the increase of nitrogen deposition in the context of climate change. We collected the soil samples of serious degraded meadow (bare land) and three plant species (*Miscanthus sinensis*, *Fimbristylis dichotoma* and *Carex chinensis*) which had been used to restore of degraded meadow in Wugong Mountain. And then put the soil samples to the six of constant temperature and humidity incubator. Three of that set different temperature (15°C, 25°C, 35°C). Another three also set different temperature, and adding nitrogen (4gN.m⁻²) respectively. The results showed the CO₂ emission rates were increased by vegetation restorations, decreased (*Miscanthus sinensis*) by N deposition, and increased by warming. There were similar CO₂ emission rates for the three grass species at 15°C and 25°C, the *Miscanthus sinensis* at 35°C have the lowest CO₂ emission rates compare to other restoration species. Soils from the *Fimbristylis dichotoma* and *Carex chinensis* plots had higher N₂O emissions than bare land or *Miscanthus sinensis* plots, especially at 25°C. The *Miscanthus sinensis* have the lowest soil N mineralization rate while haven't affected by N deposition.

T08-P09 - Recovery of biocrusts enhances the soil organic carbon storage of desert grassland in northern China

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Understanding soil organic carbon (SOC) pools and their spatial distribution density is useful to predict future carbon sequestration potential during restoration of degraded ecosystems. In this study we examined the distribution of SOC using 600 soil samples (200 samples from grazed sites and 400 from enclosure sites) in the Tengger Desert, northern China. The average density of SOC in 0~100 cm soil layer was 2.16 kg m⁻² far less than the mean level of grassland in China (8.5 kg m⁻²) and global temperate grassland (13.3 kg m⁻²). However, only about 24% distributed in the 0~20 cm surface soil. Biocrusts are a soil-surface community of cyanobacteria, lichens, mosses and other organisms, and well developed in desert grassland. These organisms are major contributors to whole-system nitrogen fixation and carbon fixation and they enhance mineral nutrient content of soils and associated vascular plants. Enclosure for banning grazing is an effective approach to restore desert grassland which has been employed in the study site since 2000. The results indicated biocrusts were markedly recovered during enclosure. SOC storage was positively correlated with biocrust cover and composition. The highest SOC storage occurred in the soil with lichen-moss dominated crusts, while the lowest of that in the soil with cyanobacteria dominated or bare soil, which can be attributed to biocrusts roles, such as increasing soil stability and fixing carbon. The annual carbon fixation was 11.36 g C m⁻²yr⁻¹ for cyanobacteria crusts and 26.75 g C m⁻²yr⁻¹ for lichen-moss crusts. These findings suggest the recovery of biocrusts is expected to significantly increase carbon input into desert grassland.

ABSTRACTS / VIDEO PRESENTATION

A Success Case of Large Scale Restoration: Reflorestar Program

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In the state of Espírito Santo, Brazil, a governmental initiative named Reflorestar Program was created in 2011 and it aims to promote hidrological security through forest restoration and conservation and allowing opportunities and income for the rural landowner via payment for environmental services. The program targets are eighty thousand hectares of conservation and restoration areas until 2018 and, partners, such as the landowner, who participates in the Program, The Nature Conservancy and other institutions, are important to leverage the projects and reach these goals. Therefore, this video covers some topics, such as: the change in land use, conservation and restoration, economic land use in conservation areas, ecosystem services. The video is a short documentary recorded in December 2016 with testimonials of partners and landowners that are working together for forest restoration aiming to ensure water security to Espírito Santo state. The work shows about the Reflorestar Program and the good experiences on field and the passion landowners have for preserving their lands, improving their production and help to conserve watersheds.

Brazilian savanna restoration by direct seeding in Chapada dos Veadeiros National Park

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The Ecological restoration of grassy ecosystems, like the Brazilian savanna “Cerrado”, is challenging, because invasive grasses are superior competitors. Also it is need to reintroduce different growth forms, as native grasses, forbs and trees. At Chapada dos Veadeiros National Park, Central Brazil, a pioneer savanna restoration in Brazil is being carried for 5 years and has restored 70 ha. A net of seed collectors was established recently and several scientific studies were set. This video shows the procedure of savanna restoration by direct seeding methods. With “Rede de Sementes do Cerrado” funding, in 2014 we made professional filming and photographic records of seed harvesting, laboratory processing, storage, soil preparation and direct seeding in the field. We also included interviews with staff like seed collectors, researchers and students. The video was edited as a guide for restorationists to use direct seeding in other savannas.

Demonstration forests: How to rebuild the Brazilian pine ecosystems?

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The Brazilian (or Paraná) pine (*Araucaria angustifolia*) forests covered an original area of 233,000 km². But now remains just 3% of this ecosystem (80% in less than 50 ha remnants), especially in the uplands (altitudes: 500-1,800 m) in south Brazil and northwest Argentina. The human settlements in the Paraná state were based on *Araucaria* timberlands and people generally also eat its seeds generally produced by unsustainable management, which reduced its genetic variability, enlisting it as an endangered tree. Brazilian restoration projects in subtropics regions where frosts are common are still not well documented. We demonstrate three restoration treatments: 1) passive; 2) nucleation (set of techniques applied just in 1/3 of the area: artificial perches and shelters for animals; seed bank and rain seedlings planted in islets; cover crop, bromeliads and 36 trees spp. islets); 3) plantation using fast (10 spp.) and slow (60 spp.) -growing tree species planted in lines. Treatments were implanted in twelve 54x40 m plots totaling 1ha of restored forest by treatment. The demonstration forests area at the Universidade Tecnológica Federal do Paraná, municipality of Dois Vizinhos (ecotone between *Araucaria* and seasonal forests) was used for decades for

pasture and crops, before the clear cutting applied to start this project. After 7 years, we show clearly visual differences between treatments where we can note a gradient (passive < nucleation < plantation) of height, density, resistance to invasive species, diversity, besides costs. Finally, restored subtropical forests will still take decades or even centuries to recover its complex highly biodiversity original ecosystem.

Direct sowing for restoration in Brazilian Cerrado

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Natural areas of the Cerrado Biome have been intensively converted into agriculture and pasture. As a result, many protected areas still have to be restored for legal suitability. Direct sowing is an alternative technique to seedlings plantation, which could reduce costs and accelerate restoration. A restoration study is being conducted in areas dominated by exotic grasses located along the reservoir of the Serra do Facão Hydroelectric, Catalão – GO. Seeds were collected in forests and savanna fragments of the region during 2015 and 2016. We eliminated the exotic grasses and plowed the soil in four sites to compare different techniques of direct sowing and post sowing management. We planted two different groups of native plants: fast growing species, late cycle species, and a third group of green manure legumes species. The seeds were sowed in lines or in the whole area in distinct plots of 1.8 x 3m. Between these plots, separately lines of seedlings of fast growing and late cycle species were planted. We are evaluating germination, survival and vegetation cover in these different treatments. We are also mowing exotic grasses that are recolonizing the area to reduce competition and ensure good seedling development. The video will show how the sowing was conducted and the site condition after six months. This video will narrate the details of the project and its development.

Kelp restoration in Tasmania, Australia: The importance of intraspecific facilitation of kelp resilience

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The kelp *Ecklonia radiata* is the most widespread habitat-forming macroalga in temperate Australasia. The underwater forests created by this species provide physically complex habitats that support extremely productive food webs with high levels of biodiversity and endemism. However, kelp forest habitats in many places in Australia (and elsewhere) are under threat and experiencing degradation in response to a variety of stressors. To examine how habitat degradation affects the population dynamics and resilience of kelp forests, we conducted a unique experiment consisting of an array of 28 artificial reefs of different sizes covering 1.6 ha and onto which we transplanted over 500 adult kelp at a range of densities. We found that healthy kelp forests facilitate their own resilience by modifying the physical environment (e.g. light, sedimentation, water flow) in ways that benefit juvenile kelps developing beneath the canopy. However, habitat degradation through reductions in patch size and kelp density impairs the ability of adult kelp to provide local conditions that facilitate the next generation. This project illustrates how the resilience of kelp forests begins to erode as they are degraded, and emphasises the importance of harnessing internal feedback mechanisms to restore habitats to be self-sustaining. By developing a novel method for transplanting kelp, we also hope to have provided a practical foundation for future restoration efforts. This research has improved understanding of the population dynamics of kelps, and provided information that will significantly assist the conservation and restoration of these important ecosystems.

Learning from Nature: The Agua Salud Project

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In partnership with the Panama Canal Authority, the Panamanian Ministry of the Environment, the US Geological Survey, the

University of Wyoming, and Potsdam University, the Smithsonian Tropical Research Institute (STRI) began the Agua Salud Project. The Aqua Salud Foundation in Panama gave STRI the use rights of approximately 650 hectares of land to undertake a long term study of ecosystem services in the Panama Canal Watershed. Scientists quantify different services and undertake basic and applied research to understand ecosystem function in the provision of ecosystem services in order to develop next generation models to predict ecosystem services in tropical steepland watersheds. Research is organized around three intersecting pillars that also afford studies of linkages and trade-offs: hydrology, secondary forests, and restoration. Socio-economic research cuts across all three pillars. This video gives an overview of the Agua Salud Project. The video will be in a format that is viewable on YouTube.

Measuring light interception and canopy cover in forests undergoing restoration

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Methods for assessing light interception and canopy cover have gained increasing relevance for monitoring forest restoration, since they provide integrative overview of ecological processes like carbon uptake, competitive exclusion of ruderal species, successional development and habitat provision for wildlife. Nevertheless, commonly, instruments for measuring both of these variables are mistakenly used interchangeably. It could work for young restoration forests, where canopy is not completely closed, thus there might be strong correlation between light interception and canopy cover. However, assuming canopy cover as a surrogate of light interception does not work for older forests with various layers of leaves within their canopies. In this video, we will present the use of commonly adopted instruments to measure light interception and canopy cover. Ceptometer and red to far red ratio sensor are proper for measuring light availability in the understory. However, both require specific times of the day and weather conditions to work. Moreover, ceptometer needs paired sensors for its measurements. Densitometer and hemispheric imaging assess canopy cover. The former is less expensive and does not require specific weather conditions, however it is somehow subjective and demands longer time in the field. The latter does not require much field work, but demands processing time and does not work well under direct sunlight. We expect to didactically expose those methods and the proper weather conditions to use them, in order to help whoever needs to make a decision about which to use for measuring light interception and canopy cover in forests undergoing restoration.

Native and exotic grass competition in restoration of Cerrado (Brazilian savanna).

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The major challenge for restoration of grass vegetation of the Cerrado biome (Brazilian Savanna) is the competition with invasive exotic grasses, which is used as pasture in Brazil. They are difficult to eliminate especially because of its long-lived seed bank. In a Brazilian national park more than 100 ha is being restored by direct seeding since 2012, giving a unique opportunity for evaluating direct seeding, and for understanding competition between native herbs and exotic grasses. In this area, we established two field experiments, testing if this competition and vegetation groundcover is affected by (1) native functional group seeded and (2) initial proportion of natives and exotic grasses. Exotic grasses were eliminated before seeding, but arose again because of the seed bank. Functional group is not affecting competition until now. In the second experiment, plots are becoming homogeneous, with same proportion of coverage of natives and exotics. This indicates that initial proportion doesn't affect competition, but both natives and exotics can disperse and colonize new plots. These results give relevant information for improving direct seeding methodology. We are producing a video to divulge these results for managers, scientific community and general public, thus, using simple language, but with the necessary information. The entire video will be a sequence of footages illustrating all the topics, explained by narration. We start briefly explaining the restoration project and the direct seeding technique. Then, we present the experiments, its results, and practical and ecological implications.

Peatland restoration for prevention of peat fires and climate change mitigation

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Extensive peatland drainage causes land degradation and raises vulnerability to fires. In Russia drained and abandoned peatlands are concentrated in the most densely populated central part of its European territory making up several hundred thousand hectares. The frequency of peat fires in this part of Russia is growing over last decades as a result of climate change and inappropriate management of peatlands. According to our estimates only in 2010 forest-peat fires affected over 10,000 ha of drained peatlands in Moscow Region alone and caused huge social and economic impacts including health problems with increased mortality from cardiovascular and pulmonary diseases. The main cause of peat fires is human factor. Peatlands are non managed and stay dry the most time of the year. The German-Russian project “Restoring peatlands of Russia for fire prevention and climate change mitigation” funded by the International Climate Initiative and implemented by KfW and Wetlands International deals with ecological restoration of unused drained peatlands in Russia. It has helped to develop rewetting designs and implement restoration measures on the area over 40 000 ha. The project strives to establish long-term capacity of Russian institutions to tackle the problems by development of suitable methodologies, improvement of scientific knowledge via joint Russian-German research, training and international exchanges as well as formulation of recommendations for policy and legislative reforms needed for restoration and sustainable management of peatlands including assessing the potential for paludiculture (wet agriculture) and trading in carbon credits derived from reduced GHG emissions from peatlands.

Restoration of rare wetland habitats in Israel involving local communities

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Natural areas in Israel are dwindling, which results in increasing threat to habitats. Rain-pool habitats are found mainly in the central coastal plain, where most of urban development is concentrated. My research focused on restoration of red-loam soils flora and rain-pool. The study was carried out at Tel Aviv University, and its findings were implemented by Tel Aviv Municipality. My research was conducted on an unexploited agricultural land, where we examined ways by which flora of disturbed red-loam soil and rain-pool habitat can be rehabilitated. We analyzed the effectiveness of an agrotechnical method for rehabilitation of formerly cultivated land while reinforcing local vegetation and assessed the ecological functioning of a rain-pool ecosystem receiving agricultural rainfall drainage. The change in the vegetation’s composition and richness showed that where a layer of 30cm topsoil was removed, a pronounced reduction in the seed bank of unwanted species (ruderal species) was achieved. Furthermore, the high clay content in the pool resulted in a long hydroperiod and the newly constructed rain-pool functioned flawlessly (normal development of flora and fauna, including species unique to this habitat). Rehabilitation of disturbed habitats has a greater chance of realization if implemented in the form of a community park. That is, nature conservation built with the community, which takes part in its planting, maintenance and protection, thus reinforcing the public’s awareness and consideration for local biodiversity. This research allows me to integrate both disciplines of ecology and landscape architecture in a successful restoration of habitats in urban and open spaces.

Ten years of restoration via direct seeding in Xingu headwaters

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The headwaters in the Xingu Basin have been heavily deforested over the last two decades. Aiming to restore these areas, the Socio-Environmental Institute (ISA) introduced the Y Ikatu Xingu project, which is being conduct to restore deforested headwaters of the Xingu River since 2006. Embrapa, University of Brasília and ISA established a partnership to evaluate the ecological outcomes of this practice. The main method utilized to restore these areas was direct sowing native trees. Our goal is to evaluate the trajectories and dynamics of areas in which the process of restoration is in progress. We are sampling areas that were restored in different years in a latitudinal gradient in the eastern region of the Xingu River, in a transition zone between Cerrado

and Amazon. In the video we are going to show the context in which these areas are found in the different counties that we are visiting. The video will illustrate the aspects of areas in a chronosequence and the sampling method. The vegetation structure of sites being restored changes with time, in the video it will be possible to see this changes and the different scenarios that are possible. Our message to the viewer is that, after ten years of restoration, science is being used to evaluate and suggest new directions for the practice, which can bring even better results. The video will be a sequence of footages illustrating all the topics, narrated in simple and accessible language, and will contain background music.

The longest biodiversity Corridor on Earth

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The goal of the Black Jaguar Foundation (BJF) is to help implement the Araguaia Biodiversity Corridor, the longest of its kind on Earth (2.600 km long and up to 40 km wide). It consists of the Cerrado savanna and Amazon rainforest in Central Brazil.

The BJF will help restore the degraded areas along the Araguaia and northern Tocantins rivers by building win-win partnerships with landowners. Local nurseries will be set up to provide seeds and seedlings of native species to recover all degraded areas, in such a way that these new forests will fully integrate into the existing forests.

The BJF focuses on three crucial tasks. The first task consists of mapping the corridor zone to identify landowners. The second task is to produce in-depth studies to determine the right combination of native trees in each area. The BJF will also set up an Ecological Agriculture Knowledge Center to help landowners transition to sustainable farming while increasing their productivity. The third and final task is the reforestation itself. All the information gathered will be turned into replantation models and offered to local landowners, including instructions on planting techniques.

Pilot project to be presented:

In 2016, together with technical partners LERF/ESALQ/USP and Bioflora, the BJF launched a 6.000ha pilot project to map and restore the degraded areas of 6 properties within the Araguaia Corridor. We have produced the PRADA for each farm concerned. In 2017, the BJF will carry out the full restoration of these zones, by planting the first 150.000 native trees.

Twenty years in ten: can we shorten the time for the restoration of ecological processes?

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Restoration is a long-time process to establish conditions for natural recover of the ecological auto-sustainability. With the objective to restore ecological processes in a short time, we evaluate a restoration in the dense-diverse functional model (DDF) in a region of Brazilian southeast dry forest. The DDF model seeks to recreate the ecological functions, beauty and diversity of the natural forest since its first years. Tree and shrubs species were chosen from local forest communities to restore a multilayer structure. After that we selected the species based on functional traits and ecological services such as pollinators and dispersers attraction, input of nutrient and biomass and nitrogen fixing. An equal proportion of intermediate-late successional and pioneer species were mixed and densely planted (3 plants/m²). To compare species at the same conditions, in five plots (0.423ha, 0.605ha, 0.489ha, 0.432ha and 0.590ha) we prepared the soil by extracting a 1 m deep and adding successive layers of topsoil until the central part reached a height of one meter. In 2011, we planted 142 species, and trees were distributed in the central part of the plots and the treelets and shrubs on the sides. Along five years we monitored a local fragment and 5116±529 individuals of 140 species of the DDF using a standard protocol of ecological sustainability. Ecological processes related to structure and functional characteristics were similar to the monitored 20-year initial secondary dry forest.

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