SLU

3rd conference

Restoring Forests

Regeneration and Ecosystem Function for the Future

Program and book of abstracts

Lund, Sweden
12-14 september 2017

3rd conference Restoring Forests - Regeneration and Ecosystem Function for the Future 2017

Report 51, Southern Swedish Forest Research Centre

3rd conference

Restoring Forests

Regeneration and Ecosystem Function for the Future

Lund 12 - 14 sept 2017

Semi-natural mixed forest on former pasture land, southern Sweden (Photo: Magnus Löf) Dutch Elm disease (Photo: Johanna Witzell)
Cover photo:Degraded Mongolian landscape, in need of forest restoration (Photo: Palle Madsen)

3rd Restoring Forest: Regeneration and Ecosystem Function for the Future

12-14 September 2017, Lund, Sweden

Organizing committee
Magnus Löf, Swedish University of Agricultural Sciences (SLU), Sweden
Johanna Witzell, Swedish University of Agricultural Sciences, Sweden
Palle Madsen, Forest and Landscape College, University of Copenhagen (KU), Denmark
Marek Metslaid, Estonian University of Life Sciences, Estonia
Douglass F Jacobs, Purdue University, USA

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Involved IUFRO units and other networks
North European Regional Office of the European Forest Institute (EFINORD) –Nordic Forest Research (SNS), Nordic Network of Forest Regeneration
IUFRO task force – Adaptation and restoration under global change
IUFRO unit 1.06.00 – Restoration of degraded sites
IUFRO unit 1.01.00 – Temperate and boreal silviculture
IUFRO unit 1.01.06 – Ecology and silviculture of oak
IUFRO unit 2.01.15 – Whole plant physiology
SLU Faculty of Forest Sciences research school – Bioeconomy – adapted forest management

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Left: Planting of Norway spruce on heathlands in southwestern Sweden ca 1930 (Photo: Lars Tirén, Forest library archive, SLU)
Below: Mixed temperate broadleaved forest in central Europe (Photo: Magnus Löf)

3rd Restoring Forest: Regeneration and Ecosystem Function for the Future

Tuesday 12th September 2017
7:30-9.00. Registration
9.00-9:15. Welcome speech by Organizing Committee
(Moderator: Magnus Löf, SLU, Sweden)
9:15-09:45. **Inaugural talk**: *New Generation Plantations: Restoring forests and ecosystem functions at the landscape scale.* **Luis Neves Silva**, WWF International, Switzerland.
09.45-10.15. **Inaugural talk**: *Saving the Bonn Challenge from Irrelevance.* **John Stanturf**, USDA Forest Service, USA.

10:15-10:30. Coffee break

Session 1: Learning from the past (Moderator: Magnus Löf, SLU, Sweden)
10:30-11:00. **Keynote speaker**: *Using the past as a guide to forest restoration.* **Richard Bradshaw**, University of Liverpool, UK.
11:00-11:45. Oral communications
• *A general framework for quantifying the effects of land-use history on ecosystem dynamics.* **Leen Depauw**, Ghent University, Belgium.
• *The vexed question of choosing an historical context for restoration: the case of the Florentine Valley.* **Mark Hunt**, University of Tasmania, Australia.
• *Using ecological memory to restore forest ecosystem resilience.* **Colin Bergeron**, University of Alberta, Canada.

Session 2: Ecological knowledge supporting forest restoration (Moderator: Douglass Jacobs, Purdue University, USA)
11:45-12:15. **Keynote speaker**: *Ungulate browsing from a nutritional ecology point of view and implications for forest restoration.* **Annika Felton**, SLU, Sweden.
12:15-12:45. Oral communications
• *Natural regeneration of Pinus pinaster to protect Quercus ilex plantations against excess ungulate browsing.* **Barbara Mariotti**, Università degli Studi di Firenze, Italy.
• *Coniferous main tree species as a deer browsing refuge for an oak admixture: Silvicultural implications for forest restoration.* **Jakub Borkowski**, University of Warmia and Mazury, Poland.

12:45-14.00. Lunch

(Continuation session 2, Moderator: Douglass Jacobs, Purdue University, USA)
14:00-14:30. **Keynote speaker**: *Understanding species interactions to support forest restoration in a changing world.* **Lorena Gomez-Aparicio**, CSIC, Spain.
14:30-16:00. Oral communications
• *Recalcitrant soil conditions; alternate states persist in woodland restoration.* **Thomas Baker**, University of Tasmania, Australia.
• *Trade-off between vitality and diversity of associated fungal endophytes in Pedunculate oak (Quercus robur L.).* **Marta Agostinelli**, SLU, Sweden.
• Linking tree water use to rooting depth, leaf area and climate on a boreal reclaimed mining site. **Morgane Merlin**, University of Alberta, Canada.

• *What drives oak colonization in Mediterranean shrublands? Facilitation and beyond.* **Pedro Villar-Salvador**, University of Alcalá, Spain.
• *Seed protection through predator's smell: Developing novel repellents to avoid granivorous rodents.* **Adrian Villalobos**, SLU, Sweden.
• *Acorn dispersal by magpie (Pica pica) in a Mediterranean forest and farmland mosaic. An overlooked actor for oak woodland spread?* **Loreto Martinéz-Baroja**, University of Alcalá, Spain.

16:00-16:15. Coffee break

(Continuation session 2, Moderator: Magnus Löf, SLU, Sweden)
16:15-17:45. Oral communications
• *Size matters: A global meta-analysis on the relationship between the size of outplanted seedlings and field survival.* **Enrique Andivia**, University of Alcalá, Spain.
• *Changing the role of tree breeding and outplanting to promote forest resilience and resistance.* **Kasten Dumroese**, USDA Forest Service, USA.
• *Is local best? Testing forest tree provenancing strategies using field trials embedded in large-scale restoration plantings.* **Zara Marais**, University of Tasmania, Australia.
• *Is Populus nigra locally adapted to latitude and rainfall? Insights from phenotype screenings for drought tolerance.* **Jaime Puertolas**, Lancaster University, UK.
• *The maternal environment affects the phenological performance of tree progenies.* **Sumitra Dewan**, Ghent University, Belgium.
• *Choosing provenances for climate resilient restoration of forest ecosystems.* **Peter Harrison**, University of Tasmania, Australia.

Wednesday 13th September 2017
(Moderator: Marek Metslaid, EMU, Estonia)
08:30-09:00. **Inaugural talk (video-link)**: *When too much disturbances is too much – principles and practices for restoration forestry in heavily disturbed native forests.* **David Lindenmayer**, The Australian National University, Australia.

09:00-09:10. Break (posters put up in poster room)

Session 3: Advances in restoration and regeneration techniques and systems (Moderator: Marek Metslaid, EMU, Estonia).
09:10-09:40. **Keynote speaker**: *New mechanical approaches for the establishment of young plantations.* **Catherine Collet**, INRA, France.
09:40-10:25. Oral communications
• *Soil preparation, choice of planting spot and planting time affects early growth and survival of Picea abies seedlings.* **Kjersti Holt Hanssen**, NIBR, Norway.
• *Improving soil quality and plant performance in degraded areas using compost and superabsorbent polymers.* **Sara Martelletti**, University of Turin, Italy.
• *Tree, stand and site characteristics affecting the occurrence of lammas shoots multiple stems in field-grown Norway spruce.* **Aksel Granhus**, NIBR, Norway.

10:25-12:00. Poster session

12:00-13.00. Lunch

13:00-18:00 FIELD TRIP TO SÖDERÅSENS NATIONAL PARK AND HERREVADS MONASTERY AREA (**Jesper Witzell** and **Tove Hultberg**, Skania County Administrative Board (Busses leaves from conference venue and return by 18:00).

20:00. Social dinner

Thursday 14th September 2017
(Continuation session 3, Moderator: Marek Metslaid, EMU, Estonia)
08:30-09:00. **Keynote speaker**: *Advances in planting techniques and materials in boreal region.* **Timo Saksa**, NRI, Finland.
09:00-09:45. Oral communications
• *Should we use meshes or tube shelters when planting in semiarid environments?* **Juan A. Oliet**, Technical University of Madrid, Spain.
• *Challenges in bringing seedling-based aspen restoration to the south-western US.* **Simon M. Landhäusser**, University of Alberta, Canada.
• *Nursery conditioning seedlings for improved dry site performance.* **Owen Burney**, New Mexico State University, USA.

09:45-10:00. Coffee break

Session 4: Forest restoration following biotic and abiotic disturbances (Moderator: Johanna Witzell, SLU, Sweden).
10:00-10:30. **Keynote speaker**: *The role of disturbances in forest restoration – do we promote or counteract them?* **Anne Tolvanen**, NRI, Finland.
10:30-12:00. Oral communications
• *Restoring forests and soil function after mining oil sands in the boreal forest.* **Cindy Prescott**, University of British Columbia, Canada.
• *Agroforestry for reclamation of waste generated by alluvial gold mining in Colombia.* **Bibiana Betancur Corredor**, University of Bonn, Germany.
• *Impact of species selection and planting strategies on boreal forest reclamation sites.* **Caren Jones**, University of Alberta, Canada.
• *Anthropogenic disturbances differently impacted natural regeneration and coppicing ability in nine Fagaceae tree species in moist oak-laurel hill forests of Khasi Hills, Northeast India.* **Somidh Saha**, Karlsruhe Institute of Technology, Germany.
• *Developing an upland forest on a reconstructed watershed after oil sands mining in northern Alberta, Canada.* **Frances Leishman**, University of Alberta, Canada.
• *The effect of agronomic herbaceous plants on mine tailings structure and on the establishment of boreal forest tree seedlings.* **Dominique Barrette**, University of Quebec, Canada.

12:00-13.15. Lunch

(Continuation session 4, Moderator: Johanna Witzell, SLU, Sweden)
13:15-13:45. **Keynote speaker**: *Scientific and breeding advances in the fight against Dutch elm disease – will they allow the use of elms in forest restoration?* **Juan A. Martín**, Technical University of Madrid, Spain.
13:45-14:15. Oral communications
• *Keep it on site: Burnt wood as a key biological legacy to prompt biodiversity and ecosystem functioning and regeneration.* **Jorge Castro**, University of Granada, Spain.
• *Recovery of temperate and boreal forest ecosystems after windthrows.* **Anders Taeroe**, University of Copenhagen, Denmark.

Session 5: Restoring forest landscapes of the future (Moderator: Palle Madsen, University of Copenhagen, Denmark).
14:15-14:45. **Keynote speaker**: *Mitigating negative effects on biodiversity from clearcutting – an overview from north Europe.* **Lena Gustafsson**, SLU, Sweden.
14:45-15:30. Oral communications
• *Restoration of temperate deciduous woodland with semi-open canopy from mixed forest on abandoned agricultural land.* **Björn Nordén**, NINA, Norway.
• *Productivity, growth, and management of valuable timber plantations in humid Guatemalan lowlands: monoculture versus mixtures with Tabebuia donell-smithii*. **Boris Mendez**, University of San Carlos, Guatemala.
• *Red alder-conifer stands in Alaska: An example of mixed species management to enhance structural and biological complexity.* **Ewa H. Orlikowska**, SLU, Sweden.

15:30-15:45. Coffee break

(Continuation session 5, Moderator: Palle Madsen, University of Copenhagen, Denmark)
15:45-16:15. **Keynote speaker**: *Restoration expectations in South America: a case study in the Andes.* **Pablo J Donoso,** Universidad Austral de Chile.
16:15-17:15. Oral communications
• *Do restored native species respond to delayed plantation thinning in the Atlantic Lowlands of Costa Rica?* **Douglass Jacobs**, Purdue University, USA.
• *Climate impact of using former arable land for biomass production in different bioenergy pathways in the transport sector.* **Sylvia Haus**, Linnaeus University, Sweden.
• *Evaluating stand developmental trajectories for bottomland hardwood restoration efforts in the southeastern United States.* **Brent Frey**, Mississippi University, USA.
• *We want to restore but today we can't: Bottlenecks for the restoration of natural forests in Southern Chile.* **Jan R. Bannister**, Instituto Forestal, Chile.

17:15-18:00. Concluding remarks and discussion

Friday 15th September 2017
08:00. Post-conference tour bus leaves from conference venue and stop at Kastrup international airport, in Denmark, at 17.00.

Inaugural talk: New Generation Plantations: restoring forests and ecosystem functions at the landscape scale

Luis Neves Silva, WWF, New Generation Plantations platform, Santo André, Portugal

Introduction: A new trajectory for global forestry development must be based on solutions that enhance the ecological infrastructure of the planet.
Method: We have analysed how the New Generation Plantations (NGP) platform and concept (focuses on 4 main principles: stakeholder engagement, high conservation values (HCV), ecosystem integrity and inclusive economic development) addresses the complexities of sustainable forestry at the landscape level. This included an analysis of ten years of field studies that demonstrate that well-managed and appropriately located plantations are a key feature of healthy multi-functional production landscapes, including compatibility with conservation and human imperatives.
Results: The New Generation Plantations concept describes an ideal form of well-managed, well-placed plantations as an important component of production landscapes, providing an opportunity to restore degraded land, spare natural forest and enhance social values whilst increasing productivity.
Discussion: System-wide planning and zoning as an innovative solution in sustainable production approaches could ensure sufficient land for other uses, such as food production for local markets and biodiversity, whilst further diminishing logging pressure on natural forests and their associated communities, ecosystem services and biodiversity. The NGP experience demonstrates that the ecological and social infrastructure of mosaics provides a means to tackle the paradox that the more we advance on development, the more we fail on sustainability.
References:
Silva L., 2016. FAO, Unasylva: XIV World Forestry Congress. No. 247/248. Vol. 67 2016/2-3 pp62-66. New Generation Plantations: towards sustainable intensification.

Luis Neves Silva works since 2004 at WWF, being the New Generation Plantations (NGP) platform Lead. Luis work includes countries like Portugal, Brazil, South Africa and China, applying interpersonal skills and cross-cultural experiences into forestry work with private, public, and NGO sectors. Since 2015 Luis represents WWF and NGP at the IUFRO 'Sustainable Planted Forests for a Greener Future' Task Force, to improve the interface between science, society and policy related to planted forests. Luis co-authored 'Changes in planted forests and future global implications', published by 'Forest Ecology and Management' analysing planted forests data, and more recently published 'NGP, Towards Sustainable Intensification', at 'Unasylva' 247/248 issue, a selection of the XIV World Forestry Congress best papers. Luis experience at NGP is that the ecological and social infrastructure of mosaics provides a means to tackle the paradox that the more we advance on development, the more we fail on sustainability.

Inaugural talk: Saving the Bonn Challenge from Irrelevance

John Stanturf[1]

[1] Center for Forest Disturbance Science, US Forest Service, Athens, Georgia USA

Restoring degraded land is a major international concern and forest landscape restoration (FLR) in the context of the Bonn Challenge and related regional initiatives has been the primary policy response. The Bonn Challenge is not a treaty, hence the commitments are not binding. Nevertheless, FLR has the potential to produce co-benefits with national obligations under the Rio+ Treaties (climate change, biological diversity, and desertification) as well as other ecosystem-based approaches. In spite of these opportunities, the Bonn Challenge risks irrelevancy in three ways. Firstly, the interest of policymakers will wane over time as the cost and complexity of FLR becomes apparent. Secondly, FLR initiatives may not deliver on expectations. Realizing that it was impossible to measure significant positive change in 150 million ha by 2020, the current wording has been changed to "under restoration". Insufficient consideration of future climate means and extremes will negatively affect resilience of restored landscapes. Increasing competition for land for subsistence and commercial agriculture, water, and other development threatens sustainability of FLR. Technical capacity is often low in target countries. Thirdly, the costs of achieving meaningful restoration success is high. Current emphasis on low-cost approaches such as natural regeneration may lead to many failures when inappropriately applied. Estimates for FLR vary enormously and a conservative estimate of US$2,000 per ha suggests meeting the 350 million ha goal by 2030 will cost at least US$700 billion. Increasing accountability, developing local adaptive capacity, increasing knowledge sharing, and promoting best available science could add relevancy to the Bonn Challenge.

I'm a Senior Scientist with the US Forest Service, Center for Forest Disturbance Science, Athens. Professional experience includes manager of pine silviculture research, Union Camp Corporation and faculty positions at Penn State, University of Pittsburgh, and Cornell University. I received his MSc and PhD in forest soils from Cornell, BSc from Montana State University. I was a Lady Davis Postdoctoral Fellow at the Technion, Haifa, Israel. The Estonian University of Life Sciences bestowed on me an honorary doctorate. My current research interests are functional restoration of degraded forests; incorporating disturbance and risk into forest management; climate change adaptation; and short-rotation woody crops. I lead the IUFRO Research Group on Restoration of Degraded Sites, also Deputy Coordinator of the Task Force on Forest Adaptation and Restoration under Global Change. For the past three years I have worked on an IUFRO/WRI project on Forest Landscape Restoration as a Key Component of Climate Change Mitigation and Adaptation.

Session 1: Learning from the past

Invited presentation: Using the past as a guide to forest restoration
Richard Bradshaw, University of Liverpool, School of Environmental Sciences, Liverpool, UK

Introduction: Research into long-term forest dynamics can support restoration by revealing the outcomes of long-term 'accidental' experiments and developing a natural forest concept that can support restoration targets.
Method: Case studies illustrating insights derived from analysis of past forest dynamic processes.
Results: Significant insights gained from the past include: understanding tree migration biology and population dynamics and their relationship with climate change; characterisation of disturbance regimes including the role of fire and large herbivores; and the long-term dynamics of genetic diversity. The calculated rates of post-glacial tree spread are higher in Europe than those from North America regardless of dispersal strategy, which may be due to more rapid shifts in European climate. Fennoscandian fire regimes were predominantly climate driven until human influence disrupted them during recent centuries. Ancient DNA demonstrates the resilience and adaptability of many forest species to past climate change.
Discussion: Study of the past helps identify the processes that leave long-term legacies in current forests. Human impact through forest management and land-use change often dominates current forest dynamics, but also interacts with climate change to exacerbate biodiversity loss and compromise ecosystem integrity. Restoration strategies should look forward to address these threats and the future needs of society, but their success will be enhanced by drawing on information about the outcomes of past human impact, climate dynamics and forest response.

Richard Bradshaw is currently Professor of Ecosystem Science at Liverpool University, UK, an adjunct Professor at Lund University, Sweden and has held research and teaching positions in five different countries. He has acted as advisor on forest management and biodiversity protection to the European Union and to the governments of Sweden and Denmark. He researches into the long-term ecosystem dynamics of terrestrial ecosystems with a primary focus on boreal and temperate forests. He has made specific research contributions in disturbance dynamics, fire and the natural forest concept, ungulate-forest relationships, stand-scale successions in ancient woodlands, forests as carbon stores, the long-term development of forest genetic resources, tree migration and both human and climatic impacts on vegetation. He has over 130 peer-reviewed publications and recently wrote a book on ecosystem dynamics and services together with a dynamic ecosystem modeler.

A general framework for quantifying the effects of land-use history on ecosystem dynamics
Leen Depauw[1]

Leen Depauw*[1], Dries Landuyt[1], Haben Blondeel[1], Sybryn L. Maes[1], Michael P. Perring[1,2], Martin Kopecký[3,4], František Máliš[5,6], Kris Verheyen[1]

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Introduction: Land-use legacies are important for explaining present-day ecological patterns and processes, but we need more insight into the extent of these legacy effects to make informed decisions for ecosystem management. We developed a general framework for quantifying land-use history, which is applicable (i) to different ecological processes in various ecosystem types and across trophic levels; and (ii) when legacy data are incomplete or of variable quality.
Method: Our approach combines Markov chains and Bayesian Belief Networks (BBN) to model the dynamics of drivers of ecological processes, given a specific land-use trajectory. Markov chains allow incorporation of memory into the dynamical description of a system. BBN allow combining land-use data of different types and qualities with expert knowledge to infer system dynamics. Comobining these methods allow projecting the dynamics of driving variables through time to study their effect on the ecological processes they control.
Results: We illustrate the framework with a case study, demonstrating that past management operations are still affecting contemporary community composition, through their impact on past light levels. Our framework proved a useful tool for quantifying the effect of past land use on ecological processes and enhancing our understanding of ecosystem dynamics by including legacy effects which have often been ignored.
Discussion: In future work, the framework can be used to make well-informed management decisions for restoration of ecosystems, accounting for influences of the past. In addition, it allows investigating possible interactions between contemporary environmental changes and land-use history.

The vexed question of choosing an historical context for restoration: the case of the Florentine Valley

Mark Hunt[1]

[1] School of Biological Sciences, University of Tasmania & ARC Training Centre for Forest Value.

Martin Moroni, Mark Neyland, Thomas Baker, Timothy Wardlaw

Management of wet eucalypt forests in Tasmania, Australia, has changed from a production focus to a conservation focus in response to changed social expectations. This study considers the Florentine Valley where we contend that the present closed euclaypt forest is the first to have occurred on the site since the last glaciation and that a cessation of aboriginal burning soon after European settlement 200 years ago is responsible for the change to forest from the grassy woodland that persisted for many thousdands of years. This has important implications for conservation and restoration objectives in these landscapes.

The environment of the Florentine Valley being cool with high rainfall, is expected to support extensive rainforest development, yet it currently supports tall eucalypt forest with no rainforest understory. Qualitative observations and historical reports from those who traversed the area in the 19th Century support the view that prior to European settlement the valley contained large areas of grassy woodland.

In remnant forests that were unharvested in the 20th century there are sparse very old trees among a large cohort of younger trees. A closer examination of these remnants through measurements of tree diameters, spatial location by diameter, evidence of fire scars in combination with a closer examination of a range of other anecdotal information has provided strong supporting evidence that demonstrates that areas of the Florentine were a sparse woodland with a grassy understory and raises the question of whether this rather than closed rainforest should be the restoration objective at such sites.

Using ecological memory to restore forest ecosystem resilience

Colin Bergeron[1]

[1] Department of Renewable Resources, University of Alberta, Edmonton, Canada

Jaime Pinzon [1], Ellen Macdonald [2], John Spence [2]

[1] Natural Resources Canada, Northern Forestry Centre, Edmonton, Canada
[2] Department of Renewable Resources, University of Alberta, Edmonton, Canada

Introduction: The ecological memory embedded in biological and physical legacies remaining after disturbance provides forest resilience by directing recovery toward pre-harvest conditions. Active management of these legacies may provide opportunities for forest restoration by increasing ecosystem resilience in the face of global change. In this study, we investigate whether forest variable retention harvesting promotes the persistence of legacies related to historical wildfire events that may influence post-harvest forest recovery.
Method: We use data from seven boreal species assemblages (bryophytes, herbs, shrubs, tree regeneration, ground beetles, spiders and songbirds) collected before and up to 10 years after harvest at the large-scale fully replicated Ecosystem Management Emulating Natural Disturbance (EMEND) experiment in northwestern Alberta (Canada).
Results: Pre-harvest forest composition (measured as tree species-specific basal area) strongly reflected local fire history during the last 300 years. We showed that ecological memory embedded in this relationship has influenced the recovery of all seven species assemblages after harvest. Ecological memory effects on post-harvest recovery was stronger for plants than for animals, with spiders showing strong but temporary ecological amnesia (lack of effects of ecological memory on immediate post-harvest recovery).
Discussion: Variable retention harvest may provide a viable ecosystem-based management approach to promote forest resilience in the face of unprecedented global change. This is especially true when these approaches favor persistence of ecosystem components strongly influenced by ecological memory.

Session 2: Ecological knowledge supporting forest restoration

Invited presentation: Ungulate browsing from a nutritional ecology point of view and implications for forest restoration

Annika Felton, Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre, Alnarp, Sweden

Over the past century the success of Norway spruce production forestry has simplified the tree species composition, structure, and disturbance regimes of southern Sweden's forest lands. Due in part to the associated costs to forest biodiversity, limited recreational value of these forest stands, and concerns regarding climate change associated risks, there are increasing discussions regarding the potential benefits of diversifying these forest lands. However, a frequently cited obstacle to such restoration efforts is ungulate browsing pressure. In southern Sweden ungulate populations are high, and preferentially consume native broadleaf and Scots pine alternatives to Norway spruce production stands. Problems also exist for ungulate populations which may be declining in health due to the limited availability of suitable browse in the landscape. In this talk I will discuss the widespread practice and perceived necessity of supplementary feeding, explain the concept and relevance of nutritional balancing, and how some types of supplementary feeding may be making matters worse for both forest diversification and the ungulates. I then discuss potential win-win solutions which should maintain the health of wild ungulate populations, reduce the intensity of browsing pressure, and increase the feasibility of adopting many production forest alternatives in southern Sweden.

My research into forest ecology has involved a diverse array of forest systems around the world, at a large range of spatial scales; from the inner complexities of animal digestive physiology and plant chemistry, to landscape scale ecological dynamics and their resultant implications for forest and game management. While my projects often specifically regards animal-plant interactions and herbivore nutritional ecology, the outcomes are applicable to the maintenance of biodiversity in managed forest systems, and the ecosystem services we derive from these forests. Currently I run two large projects that combine ungulate ecology, veterinary medicine and forestry. In the first project we study how moose nutritional intake and diet relates to their condition on a population level, and how these factors depend on landscape scale availability of ungulate food. In the second project we study specifically the effects of supplementary feeding quality and quantity on the forest and the moose on a smaller geographical scale, and the nutritional process that lies behind such interactions. In addition, my research concerns several other animal and plant species in various contexts, in Sweden and abroad.

Natural regeneration of Pinus pinaster to protect Quercus ilex plantations against excess ungulate browsing

Barbara Mariotti[1]

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[3] Dipartimento di Bioscienze e Territorio, Università degli Studi del Molise, 86090 Pesche, Italy.

Introduction: In the last decades, the maritime pine bast scale, *Matsucoccus feytaudi*, has severely damaged *Pinus pinaster* in the eastern side of its distribution. In a protected area in Central Italy, a forest restoration project was designed to replace a forest canopy after clearcutting of damaged pine stands. Seven years ago, logging was followed by planting of *Quercus ilex* using 1.2-m tall tree-shelters. However, ungulate browsing pressure has restricted seedling development. In the framework of a wide evaluation of this project, we present a study about the relationships between pine natural regeneration occurring after clearcutting and oak plantation development.
Method: Data on browsing and oak growth were collected in six sample areas, specifically examining the direct and indirect protection from browsing provided by pine saplings; pine density and plant development in relation to distance from oaks were considered.
Results: Repeated browsing strongly compromises plantation success. The probability of oak seedlings being browsed, however, was lower for individuals growing among pines than for those growing in isolated shelters. Oak establishment and growth increased as seedlings grew close to vigorous pines.
Discussion: According to our 7-year results, pine regeneration was more effective in promoting oak survival and establishment than shelters. Thus, salvage logging should be avoided across excessively large areas, to allow lateral dissemination of *P. pinaster* regeneration. Long-term assessment of tradeoffs between survival from nurse tree facilitation and stress from water competition must be considered in this Mediterranean environment.

Coniferous main tree species as a deer browsing refuge for an oak admixture: Silvicultural implications for forest regeneration

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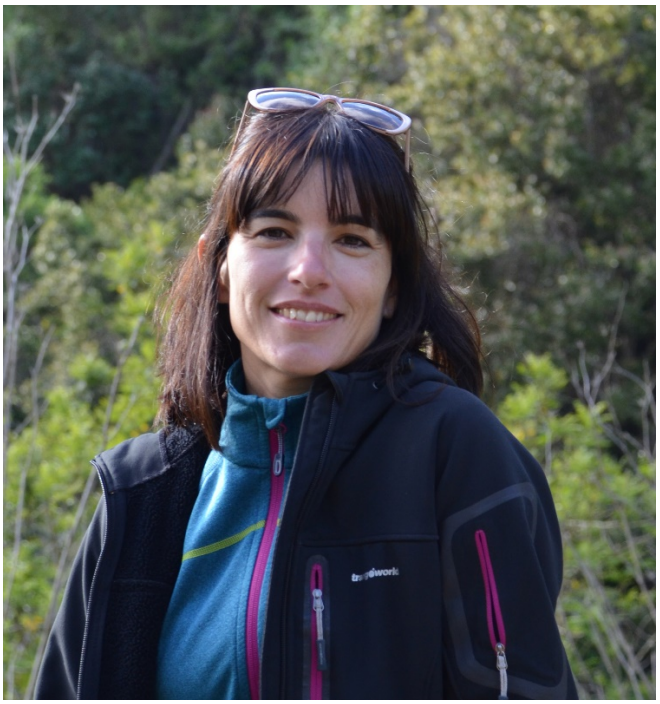
Introduction: There is little knowledge how ungulate pressure on forest regeneration may be mitigated by silvicultural methods. The knowledge is especially needed for artificially regenerated, deciduous tree species.
Methods: We studied factors affecting browsing incidence by deer in the Pisz Forest District, an area where 10,000 ha of forest was damaged by 2002 hurricane. In 2006 we established three experimental plots (in total, 22.6 ha), in which the main species was Scots pine admixed with pedunculate oak. The data on browsing were collected in 2008-2015.
Results: Oak browsing incidence was unrelated to oak planting density. In a plantation scale, it was significantly affected by the pine age. Although in each variant all the oaks were browsed for four consecutive years (2009-2012), in 2013 browsing incidence began to decrease. When the pines grew higher, it was harder for deer to move through and locate the oaks. Moreover, within plantations, oak browsing incidence was higher in the patches with shorter pines. Browsing of individual saplings/nests was also negatively affected by the pine height in the direct neighbourhood. Oak density influenced deer selectivity depending on the tree height. In a low tree density, browsing incidence was unrelated to oak height, while in higher tree density, deer selected oaks of the height between 40 and 100 cm.
Conclusion: We postulate that deciduous admixture in a coniferous (unattractive) stand can be planted with a few year delay. Older coniferous trees should impede locating of attractive tree species by deer and the browsing incidence.

Invited presentation: Understanding species interactions to support forest restoration in a changing world

Lorena Gómez-Aparicio, Spanish National Research Council, Sevilla, Spain

A main goal in the restoration of degraded forests is the recovery of the cover and diversity of a target mature plant community. Reaching such target in a short time period usually implies active planting, which makes finding suitable microsites for seedling establishment a fundamental task in forest restoration. Ecological theory developed in the last two decades around the concept of nurse-plant interactions and the Stress Gradient Hypothesis has proved extremely useful to guide the selection of planting microsites that maximize seedling survival and growth while minimizing economic costs. The application of such concepts in forests is particularly challenging though, since plant successional dynamics in these systems are more spatially complex and temporally dynamic than in dry land ecosystems dominated by perennial herbs or shrubs, where facilitation-based restoration has been more frequently applied. In forests, not only selecting the right nurse species at the time of planting can be crucial, but also managing for right densities and neighborhood composition to minimize competition as plant cover increases. Although poorly explored, indirect interactions might also play a fundamental role in forest restoration, particularly in cool temperate and tropical forests where the stress imposed by herbivores and pathogens might be of even larger magnitude than the stress imposed by abiotic conditions. In this talk I'll review our current understanding of how ecological theory on direct and indirect plant interactions can be applied to the restoration of degraded forests, and discuss how these interactions might by altered by global change drivers such as a warmer climate or the spread of exotic species.



Dr. Lorena Gómez-Aparicio is a research scientist of the Spanish National Research Council (CSIC). She received her PhD from the University of Granada (Spain) in 2004, and was a Fulbright Postdoctoral Fellow at the Cary Institute of Ecosystem Studies (NY, USA). Since 2010 she works at the Institute of Natural Resources and Agrobiology of Seville (Spain), where she leads the research group on Mediterranean Forest Systems. Much of her work focuses on understanding how Global Change drivers (mainly climate change and invasive species) might alter direct and indirect interactions among plants, animals and microbes, and how these interactions determine tree regeneration, growth and mortality. She is also very interested in applying her work to the restoration of forests and woodlands affected by disturbances such as fires, overgrazing or pathogen-driven tree decline. Her research has been mainly conducted in Mediterranean forests of the Iberian Peninsula, but she has also experience in temperate (US) and tropical (Mexico) forests. She has participated in more than 20 national and international projects, published 65 papers and book chapters (40 of them in ISI-indexed journals), and serves as an associate editor for Journal of Ecology.

Recalcitrant soil conditions; alternate states persist in woodland restoration

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Stuart MacDonald[1] Greg Jordan[1], Tanya Bailey[2], Mark Hunt[1,2]

Introduction: Variations in total soil C:N ratios highlight differences in ecosystem functioning and microbial community composition. High C:N ratios are generally characteristic of infertile native forest soils with highly conserved nutrient cycles and an ECM fungi dominated microbial biomass. In contrast, low C:N ratios are allied with fertile agricultural soils and less conserved or "extravagant" nutrient cycles that are bacteria dominated. This study tests the recovery of ex-pasture eucalypt woodland restoration soils along this continuum.
Method: We used chemical testing and Next Gen sequencing to contrast soil C: N ratios and microbial communities from restoration sites against two reference ecotypes, established pastures and native eucalypt woodlands.
Results: Both chemical and NGS data demonstrated high within group correlations. Woodland and pasture soils were significantly different meeting ecotype expectations. The ex-pasture restoration sites retained characteristically low C:N ratios, microbial communities of pasture soils and failed to demonstrate a transformational effect with planting age.
Discussion: The recalcitrant nature of these soils indicates a failure of eucalypt establishment to facilitate below ground transformation and highlights the importance of incorporating soil ecological knowledge into restoration practices to drive soil change.

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Trade-off between vitality and diversity of associated fungal endophytes in pedunculate oak (Quercus robur L.)

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Introduction: Forest declines due to epidemic diseases lead to increased proportion of low vitality trees in forested landscapes. These trees are likely to differ markedly from vital trees as a substrate for associated organisms, such as fungi. The goal of our study was to improve our understanding of the consequences of lowered tree vitality for the internal fungal communities in trees.

Methods: We studied the diversity of asymptomatic fungal endophytes in woody tissues of pedunculated oak trees. The trees were classified into three groups according to their phenotypic vitality (high, fair and reduced vitality). Endophytes were isolated from surface sterilized twigs and DNA sequencing was performed to reveal the taxonomic identity of the morphotypes. Non-metric Multidimensional Scaling was used to study the differences in fungal communities between tissue types and vitality groups, and the differences were visualized using bipartite network graphs.

Results: In xylem tissues, the frequency and diversity of endophytes was highest in oak trees showing reduced vitality. This difference was not found for bark samples, in which the frequency and diversity of endophytes was always higher than in xylem.

Discussion: Our results confirm that xylem is highly selective substrate for endophytes and that their communities in xylem are responsive to the degree of host tree vitality. In connection to regeneration and restoration efforts, strategic placement and conservation of trees with reduced vitality could be considered as a means to support valuable fungal biodiversity, but also as a potential source of latent pathogens.

Linking tree water use to rooting depth, leaf area and climate on a boreal reclaimed mining site

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Introduction: Surface mining for belowground resources in the boreal forest results in severe disturbance of the forest ecosystem, requiring landscape reconstruction before forest cover can be reestablished. Often these landforms are constructed using overburden materials considered unsuitable for plant growth, which are capped with subsoil and top soil materials that can sustain a forest cover. These sites create unique opportunities to study the impact of rooting space on ecophysiological variables in plants. As forests and leaf area develops, water availability could become a limiting factor.
Methods: In this study we link sap flow and tree productivity with soil moisture availability, rooting space and climatic drivers. White spruce (*Picea glauca*) and trembling aspen (*Populus tremuloides*) were planted on a reclaimed slope in 1999 treated with two different soil capping depths placed over saline-sodic overburden material. Trees along the slope were equipped with heat ratio method sap flow sensors over the 2014 and 2015 growing seasons. Varying tree characteristics and growth were measured, as well as soil moisture availability and weather variables.
Results: Slope position and capping depths affected the trees' wood volume and leaf area production in 2014 and 2015. Sap flow over the whole growing season showed close coupling with climatic variables for both species on both capping treatments and slope positions.
Discussion: Diurnal cycles of sap flow during dry-down and wetting-up periods provide a general and species-specific patterns of water uptake during the growing season and highlight potential consequences of reclamation practices on tree performance.

What drives oak colonization in Mediterranean shrublands? Facilitation and beyond

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Introduction: Forest recovery in Mediterranean environments is influenced by factors such as aridity, herbivory and facilitation by shrubs, as well as by seed limitation in highly fragmented forests. How these various factors interact can determine the direction of secondary succession, yet these interactions are poorly understood. We assessed the relative importance of several factors in *Quercus ilex* recruitment in *Retama sphaerocarpa* (*Retama*) shrublands at different spatial scales.

Method: We surveyed *Q.ilex* juveniles in 29 *Retama* shrublands that are distributed along an environmental gradient of increasing aridity and herbivory and are located at various distances from remnants of forest patches of different sizes. In each *Retama* shrubland, we analysed the effects of microhabitat (under *Retama* canopy *vs.* open gaps); aridity; presence of nurse shrubs; herbivory and propagule pressure, measured as the ratio between the size of forest patches and their distance to *Retama* shrubs.

Result: Frequency of *Q.ilex* juveniles increased with precipitation and was greater under *Retama* canopy than in gaps. Differences in recruitment between microhabitats increased with rainfall, suggesting a decrease in *Retama* facilitation effectivity with aridity. Frequency of oaks increased with the total area of woodland remnants located <0.5 km, yet propagule pressure did not modulate the positive effect of *Retama* and rainfall on recruitment. Forest patches at distances >0.5 km did not contribute to recruitment.

Discussion: Presence of *Retama* and dispersal processes at local scale are main drivers of *Q.ilex* colonisation of shrublands. However, facilitation by *Retama* is much weaker when both aridity and herbivory are high, regardless of seed source availability.

Seed protection through predator's smell: Developing novel repellents to avoid granivorous rodents

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Introduction: Increasing efficiency of forest restoration by the use of direct seeding has gained major interest in the forest sector worldwide. Seed-based forest restoration intendeds to reduce operation costs by more than 50% in temperate forests across northern Europe. However, seed consumption by the granivorous rodents: *Myodes graleorus* and *Apodemus sylvaticus* present a major drawback to implement this technique. We aim to identify novel volatile organic compounds from the smell of predators which could be used as potential repellents to deter those granivorous rodents from forest restoration sites

Methods: Samples of feces and fur from different mustelids (e.g. mink *Mustela vision*, stoat *Mustela erminea* and ferret *Mustela putorios furo*) are to be analyzed at the Department of Plant Protection Biology in Alnarp, Sweden. Continuously, after identifying relevant odor volatiles, behavior experiments with different rodent species will be carried out using synthetic generated predator volatiles in a hole-board arena set-up. Finally, field experiments are planned to investigate the rodent deterrence by selected odor compounds and possible side effects on seed germination.

Results: Preliminary results show high rodent repellency of mink excrement, but no significant negative effects on acorn germination. Here we present the first volatile compounds from fur and feces of mustelids.

Discussion: Our major goal is to increase the understanding of the prey-predator interaction dynamics and how its appliance could enhance seed-based forest restoration.

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Acorn dispersal by magpie (Pica pica) in a Mediterranean forest and farmland mosaic. An overlooked actor for oak woodland spread?

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Introduction. The magpie is the most common corvid in Eurasia, which distribution overlaps with the distribution of many *Quercus* species. We assessed acorn dispersal of the magpie in a woodland and farmland mosaic.

Methods. The study was conducted in Central Spain in a *Q.ilex* plantation surrounded by old-fields dominated by annual herbs. We used bird ringing, trail cameras and acorn radio-tracking to assess magpie behaviour and acorn caching microsites.

Results. Magpie individuals can disperse thousands of acorns per season. 86% of removed acorns were cached. Dispersion was made exclusively by magpie territorial adults and mainly by males. Dispersal shadow was confined to nesting territories, which constrained the availability of environments and microsites sites for acorn caching. Magpies dispersed acorns in 59% of the studied territories. Magpies used loose soil, small stones and litter for acorn caching. Mean dispersal distance was 31 m, ranging 1-112 m. Magpie acorn caching preference decreased from tilled sites to tree plantation and old-fields. In the tree plantation, magpies had similar preference for sites under tree canopy and gaps. In the old-fields, magpies frequently chose ant and rabbit pellet dumps to cache the acorns.

Discussion. The magpie is an acorn scatter-hoarding corvid that follows a hierarchical decision-making driven by magpie territories and available environments and sites in them. Magpie territory properties and its position in space drive acorn dispersal distance and caching sites. Understanding acorn dispersal pattern by magpies may be relevant for oak restoration of agricultural landscapes.

Size matters: A global meta-analysis on the relationship between the size of outplanted seedlings and field survival

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Introduction: Plant morphology can drive the survival of outplanted seedlings in forest plantations. Particularly, plant shoot size is widely used to discriminate low quality seedlings. No clear consensus exists, however, whether increasing shoot size enhances outplanting survival potential, and what factors may affect the relationship between field survival and plant size.

Methods: We conducted a global meta-analysis of the published literature to assess the relationship between initial seedling size at the time of outplanting and subsequent survival. We also investigated whether aridity, stocktype (bareroot vs. container), plant functional type (angiosperm vs. gymnosperm), site preparation intensity, and previous land use modify the survival-seedling size relationship in dry and wet ecosystems, respectively.

Results: Globally, survival was positively correlated with seedling size (r = 0.60 ± 0.07). In dry ecosystems, the magnitude of the positive correlation increased with aridity, whereas the opposite trend occurred in wet ecosystems. The reduction in the magnitude of the positive correlation with decreasing aridity in dry ecosystems was greater in angiosperm than in gymnosperm, and greater in woodlands than in croplands or in plantations involving an intensive field preparation. In wet ecosystems, the positive effect of seedling size on survival was lowest for angiosperms grown in containers and highest for bareroot seedlings outplanted on croplands.

Discussion: For plants of similar age, planting larger seedlings consistently increases plantation survival. These findings have a great significance in nursery production and forest restoration programs, and can provide a scientific basis for a broader revision of nursery cultivation protocols.

Changing the role of tree breeding and outplanting to promote forest resilience and resistance

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Worldwide, forests are increasingly threatened by challenges presented by invasive pests, other disturbances, and rapidly changing climates that may leave them maladapted to their current locations (Dumroese et al. 2015). For decades, a primary reason for planting trees was timber production. These seedlings were often bred for faster growth, greater volumes, and resistance to native pests. Although the silvicultural model of breeding and planting has worked well for timber production (and its use continues today), its use has also diminished, particularly in the United States on federally-managed lands, as public policy has shifted management from timber production toward broader ecosystem objectives (Dumroese et al. 2005). To create and/or maintain resistant and resilient forests to these challenges, land managers and policy makers may consider shifting the focus of the model from traditional timber objectives, such as growth and yield, to objectives of increasing relevance, such as resistance to invasive pests through bioengineering and adaptedness to a broader range of climate. Outplanting such improved stock could be included as a logical extension, enhancement, of an assisted migration program (see Williams and Dumroese 2013).

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Is local best? Testing forest tree provenancing strategies using field trials embedded in large-scale restoration plantings

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Introduction: 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 (Prober *et al*. 2015). Testing of these strategies before wide deployment by practitioners is important.
Method: A network of pedigreed eucalypt provenance trials has been embedded within large-scale tree plantings for restoration purposes across a highly modified rural landscape on the island of Tasmania, Australia. Over the last seven years, these common-garden trials have been established at ten sites using multiple provenances of five eucalypt species to test the local vs. non-local superiority in performance (i.e. survival, growth, reproduction).
Results: Early field trial results have revealed provenance differentiation in most performance 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. Evidence is also emerging that an exotic herbivore has the potential to impact the ecological and evolutionary trajectory of restoration plantings through the damage inflicted upon young saplings.
Discussion: These findings suggest that, in the early establishment phase, local provenances may or may not be the best choice for restoration plantings depending on species characteristics, site context and interactions with herbivores.

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Prober et al (2015) doi: 10.3389/fevo.2015.00065

Is Populus nigra locally adapted to latitude and rainfall? : Insights from phenotype screenings for drought tolerance

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Introduction: Determining whether local genotypes are best adapted to local climate is essential to delineate plant material origin zones for forest restoration projects. This is especially relevant in the current context of climate change, as assisted migration has been proposed to enhance long-term forest resilience, but the procedures to select plant material need to be examined with caution.
Material and methods: We assessed the plasticity of physiological and morphological features of 16 *Populus nigra* genotypes from different origins representing a wide latitudinal and rainfall gradient in Europe. Responses to latitude were examined in three field trials (UK, Belgium and Northern Italy), while plasticity to soil water availability was studied in the Italian field trial and a glasshouse screening.
Results: The plasticity of water use efficiency in response to latitude and the physiological and growth responses to drought were higher in genotypes from wetter climates, which explain their higher growth regardless of the growing conditions. This superior performance of genotypes from wet regions was associated with a greater capacity to conduct water and not with higher photosynthesis.
Discussion: Even though the conservative features of *Populus nigra* populations originating from dry southern regions favour water saving, they might represent a problem for plant establishment, since growth is less vigorous and this could hinder early root access to water tables. It is not clear whether local genotypes in those regions are better adapted to lower rainfall, so their transfer to northern regions to increase resilience in riparian restoration forest projects is questionable.

The maternal environment affects the phenological performance of tree progenies

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Introduction: As a result of climate change, sessile trees need to adapt to the rapidly changing temperatures. The maternal environment significantly affects the performance of progenies in a changing environment by altering their overall fitness.
Method: We studied the influence of warm (25°C) and cold (15°C) maternal temperatures during crossing, seed development and maturation on the phenology of the offspring using controlled crosses in the greenhouse. We then further assessed the phenology of the progenies in a common garden. We performed three crosses between three different pairs of genotypes of *Populus nigra* L. in three experiments using combinations of warm (25°C) and cold (15°C) maternal temperatures.
Results: We found that warmer (25°C) maternal environments negatively affect the performance of the progenies. Germination percentages of the seeds and height of the progenies that generated from a warmer maternal environment were reduced. We also observed later bud burst and earlier bud set in the progenies of a warmer maternal environment.
Discussion: The results indicate that the memory of the maternal environment is possibly retained in the offspring. Our results provide key knowledge to better understand and predict tree responses to rapid climate change and can help to better select provenances and genotypes in reforestation programs.

Choosing provenances for climate resilient restoration of forest ecosystems

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Introduction: With global climate change there is a growing view that local seed collections may need to be supplemented with non-local seed to bolster genetic diversity and thus increase evolutionary potential of restoration plantings. Here, we explore assisted migration strategies, such as the climate-adjusted provenancing strategy (Prober *et al*. 2015), as an approach for climate resilient ecological restoration of *Eucalyptus* woodlands in Tasmania, Australia.
Methods: To test the climate-adjusted provenancing strategy, software was developed (Provenancing Using Climate Analogues [PUCA] - Harrison *et al.* 2017), and key assumptions identified. We are testing several of these assumptions using large provenance collections of two *Eucalyptus* species. Functional traits were assessed from glasshouse-grown seedlings. Field performance up to two to six years after planting was assessed in provenance trials embedded within restoration plantings.
Results: Provenance variation in functional traits was strongly associated with home-site climate, with maximum temperature of the warmest week a key correlate for both species. Provenance differed significantly in field growth and survival, but the extent to which provenance performance was related to home-site climate varied. At this early stage of establishment there was a broad transfer response with most non-local provenances not significantly different in performance from the local provenance.
Discussion: We demonstrate the successful establishment of provenances after poleward and upslope translocation. These early findings are refining our species and provenance choice strategies and helping to guide future restoration projects.
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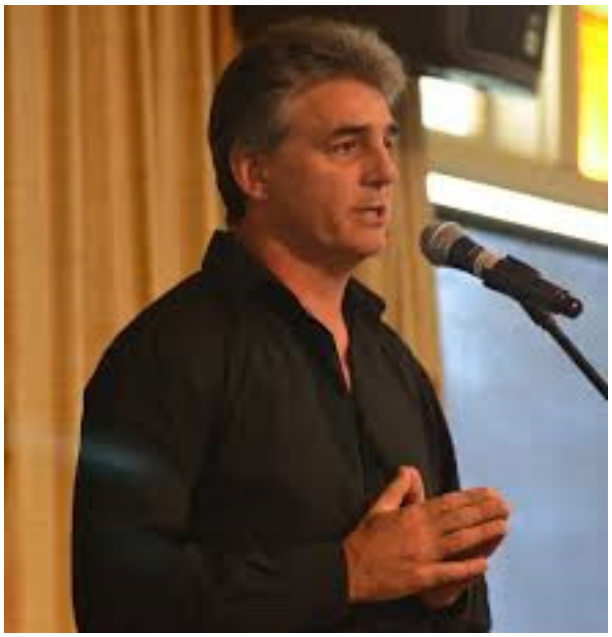
Harrison et al (2017) doi: 10.1111/rec.12488
Prober et al (2015) doi: 10.3389/fevo.2015.00065

Inaugural talk: When too much disturbance is too much – principles and practices for restoration forestry in heavily disturbed native forests

David Lindenmayer

Fenner School of Environment and Society, The Australian National University, Canberra, ACT, 2601

General principles for forest restoration must be multi-faceted and multi-scaled and encompass strategies ranging from retaining existing key residual elements of original natural forest cover (e.g. remaining populations of target species, key structures, habitats, and patches) through to restoring patterns of forest cover and key ecosystem processes. I outline how forest restoration principles intersect strongly with similarly multi-faceted and multiscale general principles for forest biodiversity conservation – in particular, those corresponding to conserving populations of particular species and their habitats, maintaining stand structural complexity, maintaining patterns of landscape heterogeneity, and perpetuating key ecosystem processes. I outline the potential for positive cumulative benefits of multiple restoration and conservation strategies by highlighting how actions at one scale can create benefits at other (smaller or larger) scales. Principles and practices are most tangible when they are illustrated with practical case studies. On this basis, I demonstrate the value of a framework that integrates forest restoration principles with general principles for forest biodiversity conservation using a detailed case study of the Mountain Ash (*Eucalyptus regnans*) forests of south-eastern Australia and the conservation of the Critically Endangered Leadbeater's Possum (*Gymnobelideus leadbeateri*). The case study highlights the important need for multi-faceted, multi-scaled and interactive strategies both for forest restoration and biodiversity conservation.



David Lindenmayer is a Research Professor at the Fenner School of Environment and Society at The Australian National University. He currently runs seven large-scale, long-term research programs in south-eastern Australia, primarily associated with developing ways to conserve biodiversity in reserves, national parks, wood production forests, plantations, and on farm land. David has written more than 1050 scientific articles, including over 630 papers in peer-reviewed international journals. He has also authored 42 books on forest ecology and management, forest and woodland biodiversity, conservation in agricultural landscapes, the ecology and management of fire, conservation science and natural resource management. He is a member of the Australian Academy of Science and the New York Academy of Sciences, winner of the Eureka Prize (twice), Whitley Award (six times), the Australian Natural History Medal, and the Servantly Medal for Ornithology. He was awarded a prestigious 5-year Australian Research Council Laureate Fellowship in 2013 and an Order of Australia in 2014.

Session 3: Advances in restoration and regeneration techniques and systems

Invited presentation: New mechanical approaches for the establishment of young plantations
Catherine Collet[1], Claudine Richter[2], Erwin Ulrich[2], Loïc Cotten[3]

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Forest plantation is a major tool to adapt forest ecosystems to global change and to restore damaged forest ecosystems. However, several barriers to a wide use of plantation to regenerate or restore forests have been identified: (1) Recurrent failure of plantation under certain site conditions (dry sites, sites with high vegetation competition, …); (2) High financial planting costs; (3) Potential negative environmental impacts of planting (soil compaction, biodiversity loss, …) and (4) Hard working conditions for tree planters. Mechanical site preparation (MSP) methods have been developed in recent years, to overcome some of these barriers and eventually improve the performance of plantation practices: (1) Technical performances of MSP were improved by designing tools to alleviate specific site constraints (control certain types of vegetation such as grasses or bracken, de-compact deep soil horizons, create mounds, …); (2) Total costs associated to MSP were reduced by improving machine productivity, and by reducing the operational and fixed costs; (3) Environmental impacts may be reduced by reducing the direct impact of machines on soil (using light-weight machines, or using rubber tracks), by reducing the surface area that is disturbed (performing localised site preparation), and reducing the number of machine trips in the stand (using combined equipment) and (4) Working conditions could be improved by replacing manual work by mechanised work, by increasing automation of machine use, and by improving machine ergonomic. Examples of innovative tools will be presented to illustrate these different methods.

Catherine Collet is a forest researcher, working at the Wood and Forest Resource Laboratory, at INRA in Nancy North-Eastern France. Her research mainly focuses on the evaluation of silvicultural methods for young forest stands, either planted or naturally regenerated. Her research also includes understanding the processes that drive forest regeneration, designing silvicultural methods to ensure regeneration success and evaluating their technical, environmental and economic performance and, finally, promoting best practices in silviculture.

Soil preparation, choice of planting spot and planting time affects early growth and survival of Picea abies seedlings

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Introduction: Spruce seedling mortality can be high due to damage from insects or rodents, as well as competition from weeds, drought, or drowning. Mechanical soil preparation has been shown to increase seedling survival and growth by ameliorating the seedling environment (Löf et al. 2012, Sutton 1993). However, soil preparation creates a specter of planting spots with different properties. Thus, the result is also dependent on the choice of planting spot within the scarified area. In addition, planting time may affect establishment conditions. This study examined whether soil preparation, planting spot and planting time affected early survival and growth of seedlings.

Method: The experiment was established at three clear-cut sites in SE Norway. Plots scarified with a disc trencher as well as unscarified plots were planted in August and September 2011 and in May 2012. Surface soil type was registered at planting. Seedling growth and injuries were then registered in autumn 2012.

Results: Site scarification affected first year height and diameter growth positively, as did planting time in the autumn. Scarification did not significantly affect the amount of pine weevil bark gnawing. However, many of the planting spots also in scarified plots were covered by a mix of humus and mineral soil. In planting spots covered by pure mineral soil, bark injuries were smaller and mortality lower.

Discussion: The results show that in order to make the most of soil preparation, the best planting spots must be chosen in the subsequent planting operation. If not, the result may become suboptimal.

IMPROVING SOIL QUALITY AND PLANT PERFORMANCE IN DEGRADED AREAS USING COMPOST AND SUPERABSORBENT POLYMERS

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Introduction: The building of high-speed railways and motorways entail the degradation of soil. Excavations and additions of inert materials lead to the formation of anthropogenic soils. These soils are usually poor in organic matter content, highly compacted due to transfers of heavy machines and vulnerable to extreme drought. In these conditions, secondary successions could be very slow, as plants do not find a suitable habitat for germination, root taking and growth. However, environmental regulation forces compensation in these degraded areas, with mandatory soil restoration and afforestation practices. For these reasons, the goal of our study was to test different mixture of soil conditioners and soil amendments to find the best solution to improve soil quality and consequently the plant performance.
Methods: We established different reclamation experiments in the Po plain, north-western Italy, planting species that characterize different stages of the original *Querco-carpinetum* forests on different substrata. We worked both in field and in germination chamber. In field, we tested the effects of compost and superabsorbent polymers on plant rooting, plant growth, and plant survival. In germination chamber, we also measured soil moisture and temperature, water holding capacity and leaching.
Results: First results showed differences between treatments, especially soil moisture, which was higher with soil conditioner, and water holding capacity.
Discussion: As plant rooting is strongly affected by soil properties, it is fundamental to find new site preparation techniques, which could improve the success of restoration projects and guarantee forest cover in the medium-long term.

Tree, stand and site characteristics affecting the occurrence of lammas shoots and multiple stems in field-grown Norway spruce

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Introduction: A second growth flush – lammas growth - sometimes occur in young Norway spruce, possibly leading to multiple tops or spike knots. Here, data from two field surveys in sapling-sized stands in southeast Norway were analyzed to find out tree, stand and site factors affecting the formation of lammas and multiple tops in young Norway spruce stands.
Material and methods: The first survey comprised 1100 spruces sampled at 55 NFI plots in the lowland Oslofjord area (<200 m a.s.l.). The second survey included 1460 spruces from 72 planted stands within the district of the forest owner association Glommen Skog.
Results: In the first survey, 25.9 % of the trees formed lammas (bud swelling or shoot elongation) at least one of the three previous growing seasons. Lammas was more frequent on high site index, was more frequent in dominant than in suppressed trees, and occurred more often in planted than in naturally regenerated stands. Half of the trees with multiple tops formed at least one of the two past growing seasons (12.8%) had developed lammas the previous autumn. The second dataset showed a lower frequency of lammas (20.8 %), and significantly only related to site index. The frequency of multiple tops was however somewhat higher, 17.7%, and about one third of the trees with multiple tops had lammas formed the previous year.
Discussion: Lammas formation was favored by stand and site conditions associated with fast growth of individual trees, and could explain a high proportion of the top damages observed in the studied stands.

Invited presentation: Advances in planting techniques and materials in boreal region
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In 1900's up to 1960's plantings were made after described burning or on no prepared soil. Seedling material was 2 to 4 year-old bare-rooted seedlings. These seedlings were cultivated on open field and usually they were transplanted once during the cultivation time in the nursery. Seedlings were planted with spade, hoe or bar.
In 1960's and 1970's mechanical site preparation started in a larger scale. First methods were disc trenching and ploughing. Mechanical site preparation gave possibility to plant containerized seedlings, which were cultivated first months/weeks in greenhouse in order to get favorable growing conditions and more uniform seedling lot. At first containerized seedlings were planted with planting hoe but soon in 1970's a planting tube was invented for this purpose.
In last decades more environmental friendly, less soil disturbing methods has been developed. In Finland different kind of excavator based mounding methods (spot mounding, inverting, ditch mounding) are most common way of mechanical site preparation today. At the same time younger/smaller seedling material has been introduced; conifer seedlings are mostly 1- to 1½-year old with container size 100 cm^3 or less. Small birch seedlings were developed first for summer planting (in 1990's) and also for spring plantings (in 2010's). In Scots pine, the use of mini-seedlings enhances cost-effectivity of pine planting, especially in northern most conditions. Today mechanized planting plays small role, but it is increasing in boreal forest. To be cost efficient mechanized planting needs proper seedling material for the whole growing season which means challenges for seedling production.

Dr. Timo Saksa has over 30 years´ experience in silvicultural research, especially in forest regeneration. Currently he is working as leader of Forest Silviculture team in Natural Resources Institute Finland (Luke). Timo Saksa has worked in Finnish Forest Research Institute (Metla) since 1982, except in years 1990-1994, when he was working in Institute for Rural Research and Training unit (Mikkeli) at University of Helsinki. In Metla he has been working several shorter times as Director of Suonenjoki Research Unit. Timo Saksa was leader of research program "Forests and Silviculture in the future (2012-2016)" in Luke and he has coordinated several research projects and received 15 research grants. He has published over 150 research articles and about 50 of them were published scientific peer-reviewed journals. He has also published several guidebooks about forest regeneration and young stand management.

Should we use meshes or tube shelters when planting in semiarid environments?

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Introduction: plant response within tube shelters is relatively well known in Mediterranean semiarid plantings, with some scientific studies providing positive empirical evidences. However, the effect of meshes is not as that well known, despite they are widespread used in plantations.
Methods: the plantation was arranged as a factorial experiment testing 1) tube shelter versus mesh, 2) two species from semiarid Mediterranean areas (*Rhamnus lycioides* and *Quercus coccifera*), and three levels of PAR light transmission (40-60-80% LT). Results from first year survival and growth, as well as ecophysiological response during first summer are reported.
Results: one year survival and biomass were superior for the seedlings in tube shelters, with a species-specific response for first of them: survival of *R. lycioides* protected by shelters resulted 40% higher than that by meshes, while survival of *Q. coccifera* in shelters was only 12% superior. Light transmission of mesh significantly affected survival, with 80% LT depleting survival in a 26%. Mid-summer photochemical efficiency measures show a higher but moderate stress over photosystem II of seedlings within tube shelter, while predawn water potential was 0.8 MPa lower in mesh, showing a higher hydric stress for seedlings within meshes.
Discussion: higher water stress of seedlings in mesh could be explained by a higher evaporative demand provoked by the reduction of the boundary layer. However, tube shelter limits air circulation, increasing temperature and depleting photosystem II performance. Survival results indicate that the magnitude of evaporative effect is higher than that of temperature, recommending the use of tube shelters.

Challenges in bringing seedling-based aspen restoration to the south-western US

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Introduction: Recent dieback and projected range contractions of *Populus tremuloides* in the western US suggests a more proactive management approach may be necessary to maintain aspen on these landscapes. Traditional silvicultural practices in this region have focused on inducing asexual suckering. Planting of aspen seedlings for restoration has proven effective in mined-land reclamation in the boreal forest of Canada, but protocols have yet to be developed for the western US where conditions are more challenging.
Method: Aspen seedling stock was produced from seed collected in Canada and the US. In the fall of 2015, seedlings were planted in high-elevation sites in southern Utah. Seedling survival and growth were monitored over two growing seasons.
Results: Although seedlings sourced from Canada had nearly 3-fold greater root to shoot ratio and higher root reserves, there were no significant differences in first year seedling survival among sources, though survival rates did vary significantly by site, from a low of 1% to a high of 47%. Primary mortality causes were early summer drought and winter rodent herbivory.
Discussion: Differences among seedling sources during nursery production suggest that protocols need to be adjusted for western US aspen. Additionally, the site differences found in seedling survival indicate a need to assess site limitations to aid in the site selection for future restoration efforts. Despite these initial challenges, further refinement of seedling-based aspen restoration techniques in the western US could prove to be a useful supplemental tool for increasing resilience through active management of this foundation species.

Nursery conditioning seedlings for improved dry site performance

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Introduction: In areas affected by disturbances such as wildfire and surface mining, planted tree seedlings can be subject to tough establishment conditions, particularly drought. Warmer and drier future climate regimes may further exacerbate these conditions thereby impeding reforestation success using conventional methods, e.g. stocktype selection and site preparation. The aim of this study is to culturally adapt a seedlings' physiology and morphology to mitigate dry planting conditions.
Methods: *Populus tremuloides* and *Pinus ponderosa* seedlings represented from 3 seed zones each were grown under 3 moisture availability levels (wet to dry) from shortly after germination to 20 wks. Physiological and morphological assessments included gas exchange, xylem hydraulics, soluble sugar concentrations, and biomass. Remaining seedlings were placed into post-transplant drought tolerance assessments.
Results: Preliminary results indicate both species altered biomass allocation and leaf physiology so as to emphasize leaf development over root development, presumably prioritizing leaf modifications which contribute to increased water-use efficiency over root system expansion. Additional data is being analyzed to better quantify xylem development and function as well as post-transplant drought stress performance.
Discussion: These early results demonstrate a capacity to manipulate more complex physiological and morphological characteristics during nursery culture than has been historically employed operationally. This includes detailed understanding of the effects of adapted nursery culture on hydraulic structure and function. The absence of interactions between drought-conditioning treatments and seed sources within each species suggest the morphological and physiological changes resulting from drought-conditioning may be inducible via nursery cultural practices for a variety of species and seed sources.

Session 4: Forest restoration following biotic and abiotic disturbances

Invited presentation: The role of disturbances in forest restoration – do we promote or counteract them?

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Boreal forests are not only adapted to disturbances, but are also dependent on disturbances in terms of their natural dynamics and regeneration. The major disturbances, fire and windstorms, promote natural succession and create habitats for species at different successional stages. Commercial forestry favoring uniform stand structure without deadwood and efficient fire control has resulted into large scale degradation of forest biodiversity. On the other hand, the vulnerability of commercially used forests to windstorms has increased, which may have dramatic economic and societal effects under changing climate. Consequently, the beneficial ecological effects of disturbances and the economic and societal losses caused by disturbances have to be balanced in forest use. In Finland the forest use still depends quite strictly on the protection status of forests. Ecological restoration is only done in protection areas, where natural disturbances fire and windstorms are imitated to increase the habitat heterogeneity. In commercial forests, fire is efficiently controlled and trees fallen by natural windstorms are collected to prevent pest attacks. Biodiversity-oriented forestry methods such as retention trees and prescribed burning have been used in commercial forests to some extent, and they have a positive effect on forest biodiversity. The updated Forestry Law also allows continuous-growth forestry, which simultaneously supports the timber production and the safeguarding of biodiversity and can increase the tolerance of forests against disturbances. In my talk I continue to discuss the twofold role of disturbances, which differs depending on the viewpoint i.e. that from ecological restoration and from forest management.

Anne Tolvanen holds a professorship in forest ecology and the multiple use of forests in the Natural Resources Institute Finland and in the University of Oulu. Her present work concentrates on the multiple land uses and the reconciliation of ecosystem services, and her group develops tools that are used in the regional planning and management of peatlands and forests. Her research also covers a wide range of ecological and socio-ecological questions in terrestrial boreal and arctic ecosystems: ecological restoration of forests and peatlands, sustainable nature tourism, and arctic vegetation responses to climate changes.

Restoring forests and soil function after mining oil sands in the boreal forest

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Introduction: Restoring ecosystem function following mining requires the development of a functioning soil, including the amount and rates of accumulation of soil organic carbon (SOC). We compare SOC content and characteristics in reclaimed soils in restored forests of *Populus tremuloides* and *Picea glauca*, and in natural boreal forests of similar age.
Methods: Concentrations of C in the upper 30 cm of soils were measured and density and size fractionation was used to separate soil organic carbon (SOC) into unprotected light fraction C, physically protected C, and chemically protected C
Results: Restored forests had six times more total SOC than natural sites, which was attributable to the peat amendment used during reclamation and the accumulation of new organic C. Restored forests also had more SOC in physically and chemically protected pools. Deciduous sites had the highest total soil carbon and the greatest light-fraction LF carbon C pool, and evidence of accumulation of new SOC through bioturbation,
Discussion: Accumulation of new soil organic carbon is facilitated by planting Populus trees.

Agroforestry for reclamation of waste generated by alluvial gold mining in Colombia

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Introduction: Alluvial gold mining operations leave vast amounts of gravel and sand waste that cover the natural soil, destroy riparian ecosystems and impact river beds and valleys. In Colombia, more than 79,000 ha are covered by this waste, hence developing strategies to restore the productivity of affected areas is crucial for the livelihood of communities.
Method: Agroforestry systems have been established for reclamation of waste deposits, combining agricultural crops and livestock to complement reforestation. Assessing changes in both deposit properties and vegetation structure as indicators of reclamation progress is needed for management. Reclaimed plots established in 2002, 2006, 2010 and 2014 were selected, soil physicochemical and hydraulic properties were determined, and measurement of vegetation height and diameter was conducted.
Results: Results show that particle size of the deposits is the main factor of variation of both, physicochemical and hydraulic properties, without significant differences across years of reclamation. In contrast, size structure of plant community significantly changed among different years of reclamation, but no significant difference was found for different particle size of waste deposits. Clay content, structural stability, pH and nitrogen are the properties that best correlate with dissimilarities of size structure of plant community.
Discussion: Results suggest that even though soil properties remain constant in the initial years of restoration, size structure of plant community has evolved. The evolution of vegetation reestablishment in our study area can be attributed to age and succession, given the limited variation of physical and chemical properties of the deposits where they are established.

Impact of species selection and planting strategies on boreal forest reclamation sites

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Introduction: Tree species selection is an important aspect of forest restoration influencing a wide range of forest ecosystem processes. The boreal forest is known for its large expanse of monospecific stands and paucity of tree species. In natural boreal forests, differences in biotic and edaphic conditions exist between single species and mixed stands, although some drivers are poorly understood. Forest reclamation areas provide a unique opportunity to explore development of forest functions in relation to canopy composition and closure.
Method: In a large, operational study we investigated how stand composition impacts early tree performance and plant community development. Aspen (*Populus tremuloides*), jack pine (*Pinus banksiana)* and white spruce (*Picea glauca*) were planted in pure and mixed-species plots at two densities (10,000 or 2000sph). Above and below-ground measures were monitored over the first five growing seasons.
Results: Above-ground variables in aspen were not affected in mixtures compared to pure plots. Pine seedlings grew better in pure plots while spruce performed better in mixtures. Aspen grew long, lateral roots regardless of composition. Spruce developed deeper roots when planted next to pine than when next to aspen or in pure plots. At this early stage, understory development has been influenced by density, with lower cover of the understory community in high density plots.
Discussion: Overall, this research indicates that tree planting prescriptions will have profound effects on developmental trajectories of forests. This unique study will provide important information on changes in stand attributes and functions for boreal reclamation sites for years to come.

Anthropogenic disturbances differently impacted natural regeneration and coppicing ability in nine Fagaceae tree species in moist oak-laurel hill forests of Khasi Hills, Northeast India
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Moist oak-laurel forests in the Northeast Indian state of Meghalaya is degrading mostly due to anthropogenic disturbances. This study had aimed to assess the impacts of anthropogenic disturbances on the natural regeneration and coppicing ability of nine Fagaceae species in an elevational gradient of 800 to 2000 m, at the windward side of the Khasi hills. Several biotic and abiotic variables (45 variables in total) were measured in the field and laboratory. The region is one of the wettest places on earth (approx. 15000 mm of annual rainfall). Twelve stands (each 0.25 ha size) from six locations were inventoried, supplemented by floristic surveys, microclimate assessments, analyses of soil physical and chemical properties. The nine Fagaceae tree species were: *Castanopsis indica, C. lanceifolia, C. tribuloides, Lithocarpus dealbatus, L. elegans, Quercus semicarpifolia, Q. glauca, Q. lineata*, and *Q. griffithii*. Increase in stand structural and compositional diversity, availability of soil nutrients' concentrations, reduction in cattle grazing and uncontrolled felling had enhanced natural regeneration of Fagaceae species. Elevation was not an important factor controlling the regeneration of these species. *C. tribuloides,* and *Q. glauca* are two mostly sensitive species to anthropogenic disturbances, whereas, others are more tolerant due to higher coppicing ability. The overall coppicing ability was higher in Fagaceae species than non-Fagaceae species. To date, silvicultural systems to manage and conserve this type of forests had not been developed. This basic study on the regeneration ecology of Fagaceae species will help forest owners to develop future strategies for forest restoration in the region.

Developing an upland forest on a reconstructed watershed after oil sands mining in northern Alberta, Canada

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Introduction: The restoration of forest ecosystems is a complex process subject to topographic and climatic conditions driving the redevelopment of soils, hydrology, and biota. The development of forested landscapes is a priority as the quick development of a continuous tree canopy helps suppress establishment of weedy species. Site conditions such as soil and topography are important factors regulating vegetation development in reclaimed landscapes.
Methods: In this study, we examined initial forest development on upland areas of a reconstructed watershed in the Athabasca oil sands region, i.e. tree growth associated understory plant community in response to different reclamation soil types (coarse versus fine textured soil) and reclamation practices (planting density, coarse woody debris) from 2013 to 2016.
Results: Survival of planted seedlings was high overall, and disparities in height growth were largely related to differences in edaphic conditions between cover soils. The direct and indirect effects of changes in edaphic conditions and vegetation cover over the years explained a significant portion of the observed performance of the seedlings. Understory species richness and community composition were different between cover soils but did not translate into differences in cover in 2016.
Discussion: Nutrient and water availability between soil types influence the observed patterns in tree growth and vegetation development. Assessing the network of relationships between variables on these reclaimed sites is necessary as this work on upland forest development will contribute to the development of sustainable and integrated reclamation landscapes.

The effect of agronomic herbaceous plants on mine tailings structure and on the establishment of boreal forest tree seedlings.

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Mining extraction in North America generates vast amounts of mineral waste, such as mine tailings, resulting in boreal forest land fragmentation. Current industry practice aiming at mine tailing revegetation uses agronomic herbaceous seeding to quickly stabilize the wastes and reduce erosion. However, it is still unclear whether agronomic herbaceous plants are conducive towards the natural establishment of boreal tree seedlings.
A complete bloc randomized design (1 hectare, 3 repetitions) was established in 2013 on thickened tailings of a gold mine (Quebec, Canada). Five treatments were tested: 100 % Graminoids, 100 % Fabaceous, mix of Fabaceous and Graminoids, forest topsoil, and control (mine tailings only). In summer 2015, 30 trees of four boreal species were planted in the five different treatments. In 2016, cores of soil substrate were sampled and analyzed for macro porosity, bulk density, and organic matter to measure the treatment effects on planted tree aerial growth, root biomass and foliar nutrients. Soil preliminary analyzes showed higher macroporosity and organic matter in the topsoil treatment compared to the other treatments. For the tree root biomass, height, and diameter measurements, willow species showed a significantly greater height in the 100 % Fabaceous treatment compared to the other treatments. Root biomass of tamarack was higher in the 100 % Fabaceous treatment compared the other treatments. Our findings will have practical implications for the establishment of boreal tree species in reclaimed mine tailing facilities using agronomics herbaceous plants.

Invited presentation: Scientific and breeding advances in the fight against Dutch elm disease – will they allow the use of elms in forest restoration?

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Elms (*Ulmus* spp.) were dominant trees in mixed broadleaf forests of many European territories, mainly distributed near rivers and streams or on floodplains. Since ancient times they have provided important services to humans, and several selected genotypes have been massively propagated and planted. Today elm populations are severely degraded due to the negative impact of human-induced changes in riparian ecosystems and the emergence of the highly aggressive Dutch elm disease pathogens. Despite the death of most large elm specimens, there is no evidence of genetic diversity loss in elm populations, probably due to their ability to re-sprout after disease. The recovery of elm populations from the remaining diversity should build from genomic tools that facilitate achievement of resistant elm varieties. Research works to date have discerned the genetic diversity of elms and are well on the way to deciphering the genetic clues of elm resistance and pathogen virulence, key findings for addressing recovery of the species. Several tolerant clones suitable for use in urban and landscape planting have been obtained through traditional species hybridization with Asian elms, and several native clones have been selected and used in pilot forest restoration projects. Successful reintroduction of elms should also rely on a deeper understanding of elm ecology, in particular their resilience to abiotic and biotic disturbances. However, all these efforts would be in vain without the final acceptance of elm reintroduction by the social actors involved, making it necessary to evaluate and publicize the ecosystem services elms can provide for today's society.

Juan A. Martín is Associate Professor at the Forestry School of the Technical University of Madrid (UPM), Spain. He has about 6 years of experience in teaching and 14 in research. His primary research interests are the study of environmental and host factors involved in the resistance of woody plants against pathogens in connection with tree breeding, with a special focus on finding elm genotypes resistant to the Dutch elm disease pathogen. He has also carried out research on the diversity, functions and biotechnological applications of endophytes of forest trees. He is having extensive collaborations within EU projects and networks, and has been principal investigator of several research projects financed by the Spanish Ministry of Economy, Industry and Competitiveness. He is co-author of 34 JCR research articles and main supervisor of two PhD and several BSc and MSc students at UPM, and co-supervisor of a PhD student at SLU. He coordinates the Forest Health Group of the Spanish Society of Forest Sciences.

Keep it on site: burnt wood as a key biological legacy to prompt biodiversity and ecosystem functioning and regeneration

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Introduction: Burnt-wood (BW) is an abundant biological legacy that remains after fires, yet it is usually extracted (salvage-logged) invoking economical or silvicultural reasons. Here, we summarize the results after 12 years of study in an area (Lanjarón fire, Sierra Nevada, Spain) where an experimental design was set up to study the role of BW on biodiversity and ecosystem functioning.
Methods: Four plots at different altitudes were established after the fire. At each plot there were three replicates of three treatments differing in post-fire burnt wood management: non-intervention, salvage logging, and an intermediate degree of intervention (felling most of the trees but leaving them in situ).
Results: BW acted as a nurse object that reduced drought stress, as reflected by higher seedling survival and growth as well as leaf isotopic signature. BW also served as a nutrient reservoir that decomposed through time and improved soil fertility and soil functioning. These processes improved ecosystem functioning, as denoted by higher primary production, higher plant diversity and animal diversity (birds and insects), and higher carbon sequestration in treatments with burnt wood in relation to salvage-logged areas. BW also mediated habitat selection by jays, which dispersed more acorns to un-salvaged areas while burnt logs remained standing.
Conclusions: The effect of BW on ecosystem functioning was complex and depended on the type of post-fire management, time since fire, and the parameter considered. Overall, its effect was positive, and absolutely relevant in many cases. We conclude that BW should be kept totally or partially after fires.

Recovery of temperate and boreal forest ecosystems after wind throws

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Wind throw is a natural disturbance factor in boreal and temperate forests and have large ecological and economic consequences. We focused on recovery processes of forest ecosystems exposed to wind throw.
We used a semi quantitative meta-analytical approach using 31 case studies and addressed four aspects of forest ecosystem recovery 1) which recovery processes dominates after wind throw, 2) which other ecosystem structures and processes influence recovery, and 3) how does salvage logging affect forest recovery
Our analyses showed that main focus of recovery processes are on post storm regeneration and survival of seedlings. Advanced regeneration also plays an important role, especially for shade tolerant species and in the boreal biome. Soil disturbance and dead wood played an important role for the regeneration of Picea sp., especially in the boreal region, whereas in temperate biomes game browsing and competition from ground vegetation seems to be the most important influencing processes. Salvage logging mostly acted as a subsequent disturbance after the wind throw, pushing the forest ecosystem towards an earlier successional stage, and hereby retarding recovery. Our analyses suggest that forests in the temperate and boreal regions generally are resilient, also when salvage logging is practiced.
Currently nature like management approaches is being introduced. However, only limited attention has been put on natural recovery processes, emphasizing the potential for a research effort related to natural recovery processes and how to prepare the forests to coming storms by restoration efforts aiming at improving forest structures enhancing recovery ability of future forests.

Session 5: Restoring forest landscapes for the future

Invited presentation: Mitigating negative effects on biodiversity from clearcutting – an overview from north Europe

Lena Gustafsson[1]

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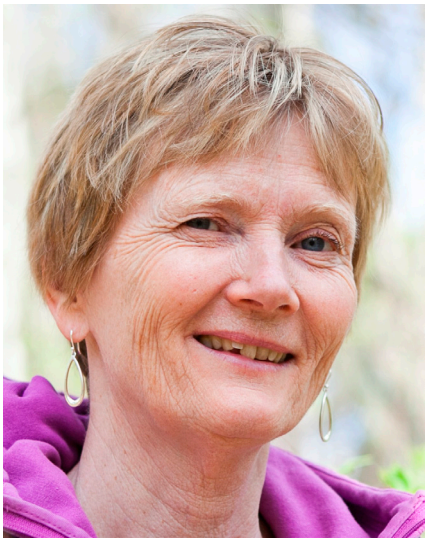
North European boreal forest landscapes are shaped by industrial forestry, practiced through clearcutting from the 1950s-60s and onwards. Extraction of all trees, rotation times rarely exceeding 100 years and reforestation (usually planting) with *Pinus sylvestris* and *Pinus abies* have reduced forest age, and homogenized stand and landscape structure. Retention approaches at final harvest were introduced a few decades ago on several continents, implying that some trees and tree patches are left at site with a main aim to promote biodiversity. This model is today common practice in the Nordic countries, with certification as an important driving force. Important objectives of the retention approaches are to (a) enrich the structure and composition of the postharvest forest (b) achieve temporal and spatial continuity of key habitat elements and processes, including those needed by both early- and late-successional specialist species, and (c) maintain connectivity in production forest landscapes. Retention can be seen as a preservation action, since natural forest elements are saved for the future. But it also relates to restoration since it creates structurally richer stands and landscapes compared to the traditional clearcutting model. Numerous studies have been performed on the biodiversity response to retention on different continents. For the Nordic and Baltic regions many studies have been directed towards dead wood but also on scattered live trees, retention patches and border zones, with beetles, bryophytes and lichens as common study organisms. I will summarize main findings, including some reviews and meta-analyses, and discuss the efficiency of the model, in relation to clearcutting but also to other forestry models.



Lena Gustafsson is professor and head of the Conservation Biology Unit at SLU, Uppsala, Sweden. Her research is directed towards processes and patterns that drive species and habitat diversity, specifically related to topical issues in forestry and conservation, and often with a focus on identifying efficient solutions. Much of her recent research has been towards the practice of integrating conservation measures at logging operations, like retaining trees and creating deadwood ("retention forestry"). Current research directions also include conservation biogeography (regionalization of conservation approaches), and post-fire vegetation dynamics. She has a large interest in outreach activities and puts a large effort into synthesizing and communication research results to end-users.

Restoration of temperate deciduous woodland with semi-open canopy from mixed forest on abandoned agricultural land

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Introduction: Land use has led to a steep decline of temperate deciduous woodland and this biome presently covers only a small fraction of its former distribution area. The recent, often mixed and dense, forests on abandoned agricultural land pose an opportunity for restoration. Canopy closure by spruce succession in these woodlands may decrease biodiversity and ecosystem services. We evaluate the effect of restoration thinning using a strong experimental (BACI) design at 13 sites in Norway and 13 sites in Sweden. We will calculate the economic potential of timber harvesting and the area of available habitat and analyze the social and environmental impacts as well as the policy opportunities of restoration.
Methods: We established one experimental plot and one control plot, each 100 x 100 m, at each site. In each plot we surveyed forest structure, standing volume, dead wood, vascular plants, insects (captured in malaise tents), fungi on dead wood, ash dieback, the number of oak seedlings, and powdery mildew on small oaks. The experimental plots were thinned in the winter 2016/2017, and up to one third of the total volume was removed, mainly Norway spruce. We will repeat the surveys in 2018 and 2019 to measure the short-term effects of the removal of spruce.
Results: The available area of the relevant forest type is significant, and yields of the initial thinning may motivate at least some land-owners. Expected responses of biodiversity based on a literature survey were mainly beneficial.
Discussion: This approach to restoration may be cost-efficient and time-saving.

Productivity, growth, and management of valuable timber plantations in humid Guatemalan lowlands: monoculture versus mixtures with Tabebuia donnell-smithii

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Introduction: inclusion of native species in the tropics is being promoted for different purposes including diversification of productive systems, expansion of species choices for reforestation, biodiversity conservation, enhancing ecosystem services and land restoration; broader use of such species is hampered by the lack of sufficient knowledge about their auto-ecology; many of these species are not able to thrive under conventional monoculture cultivation. This is the case of *Roseodendron donnell-smithii*, a cabinet timber producer, and native of the humid lowlands of Mesoamerica.
Method: performance of monoculture versus different forest and agroforest mixed plantations with *R. donnell-smithii* and other 15 species –exotics and natives, some regarded also as valuable timber trees- was tested in five locations in the humid lowlands of southwestern Guatemala; age of plantations ranged between 5 and 16 years old. Productivity at stand level and average growth rates in diameter and height for *R. donnell-smithii* individual trees were compared for the two conditions in each site.
Results: mixtures achieved consistently higher stand volume and growth rates for diameter and height for *R. donnell-smithii* in all sites.
Discussion: results show the wide range of possibilities for successful cultivation of a valuable timber native species in mixed stands in the humid tropics if ecological requirements of species are understood, although important information gaps still remain. Valuable timber production of a native species is feasible in such kind of arrangements but requires careful design and management to balance socio-economic benefits with ecological constraints.

Red Alder-Conifer Stands in Alaska: An Example of Mixed Species Management to Enhance Structural and Biological Complexity.

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Introduction: There is worldwide interest in managing forests for biodiversity, ecosystem services and sustainability. Silvicultural systems containing a mixture of broadleaf-conifer species may enhance diversity, improve wildlife and aquatic habitats, and provide ecosystem services earlier than even-aged conifer plantations.
Method: We describe single-species plantations of Sitka spruce, western hemlock and red alder. Then, we synthesize studies from mixed Sitka spruce-western hemlock-red alder stands in SE Alaska, and present their potential for improving ecosystem services *(1)*.
Results: Retaining red alder in young stands creates a multi-layered forest canopy with a few dominant overstory conifers, a mid-canopy of red alder and a lower canopy level of small conifers *(1)*. There is a strong correlation between increasing proportion of alder basal area (BA) and: a) increasing vascular plant cover, biomass and carrying capacity for deer in summer *(1)*; b) decreasing total stand BA. Stands with more even alder-conifer mixtures have the most species-rich understory vegetation, provide more food, more and safer nest sites, for bird species. Streams with more riparian alder transported more invertebrates and detritus than streams with predominantly conifer along their banks *(1)*. The number of alder woody debris pieces in streams increased with increasing proportion of riparian alder (*1)*.
Discussion: We discuss the opportunities and potential tradeoffs for managing mixed broadleaf-conifer stands for providing natural resources, and the influence of these broadleaf-conifer forests on ecosystem linkages and processes.
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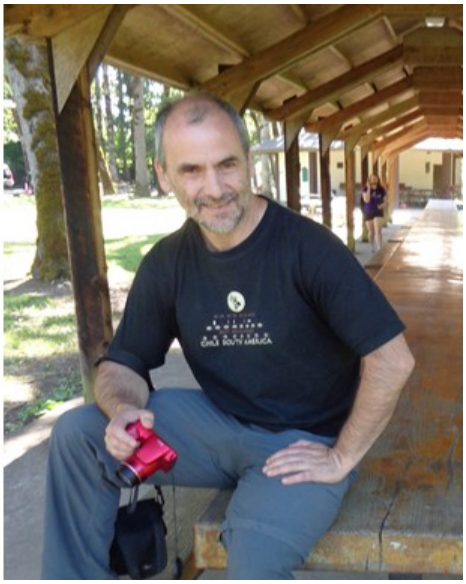
Invited presentation: Restoration expectations in South America: a case study in the Andes.

Pablo Donoso, Universidad Austral de Chile

Juan Posada, Universidad del Rosario, Colombia; Francisco Escobedo, Universidad del Rosario, Colombia; Rene Zamora, World Resources Institute

Many regions that were once covered by contiguous, productive and valuable native forests have experienced the loss or heavy fragmentation and degradation of these forests. Restoring these deforested or degraded landscapes often requires science-based information regarding reference conditions and the assessment of past and current drivers of deforestation. A science-based analysis is also needed to assess the motivation of landowners and forest managers to support effective institutions. Forest landscapes in the Andean regions of Chile and Colombia share similar climates, soil characteristics, and historic land-uses, but social dynamics between *campesinos* (small landowners) and larger landholders, rural-human settlement matrices, land management organizations differ. Forest sectors are in different stages of development. In addition both countries have extensive areas dominated by fragmented landscapes where secondary forests are the main source for future restoration of old-growth forests or to naturally regenerate deforested areas or degraded forests. Here we systematically compare: a) structural characteristics of secondary forests, b) potential of secondary forests for natural regeneration, 3) socio-ecological aspects needed to facilitate restoration (identify drivers of land use change, human-caused disturbances, socio-economics, governance, etc.) and 4) we analyze the potential economic benefits of restoration based on secondary forests. We expect that such comparative analyses can be useful in other Latin American and developing regions with similar socio-ecological contexts in order to make progress toward global and regional movements such as The Bonn Challenge and Initiative 20x20.



Pablo J Donoso is a forester from Universidad Austral de Chile (UACh, 1988), and Ph.D. (2002) at the College of Environmental Science and Forestry of the State University of New York in Syracuse (SUNY-ESF). He now is a professor at the UACh. His research during the last five years has been focused in plantations of Nothofagus species, variable-density thinnings in different types of secondary forests, and uneven-aged silviculture in mixed Valdivian temperate rainforests. He has published near 70 peer-reviewed papers and two books, mostly in forest ecology, silviculture and restoration in native forests. He is now especially concerned in cooperating to develop strategies for a sustainable forest management in Chile, by promoting both management of native forests and landscape restoration in areas with industrial plantations. Pablo is a member of the World Resources Institute advisory panel on the use of native species in restoration projects.

Do restored native species respond to delayed plantation thinning in the Atlantic Lowlands of Costa Rica?

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Introduction: Lowland Costa Rican forests have been extensively cleared for conversion to agriculture and to harvest timber. Plantations help to sustain timber flow and restore degraded lands, and native species have been identified that may equal or exceed performance of fast-growing exotics. Despite governmental funding initiatives to reforest with native species, many of these plantations do not receive timely thinning treatments that may yield intermediate timber resources and sustain rapid plantation growth
Method: We studied response of four commonly planted native species to delayed (eight to nine years since establishment) plantation thinning (to 50% of original density) relative to a control treatment (no thinning) in the Atlantic Lowlands of Costa Rica.
Results: Volume extracted from thinned trees of *Calophylum brasiliense* and *Hyeronima alchorneoides* mainly consisted of pole logs (38-46 m^3 ha^{-1}), while *Terminalia amazonia* and *Vochysia guatemalensis* produced both pole logs (50-72 m^3 ha^{-1}) and merchantable sawlogs (26-60 m^3 ha^{-1}). After one year, all species responded similarly to the thinning treatment, with no increase in total height (excepting *C. brasiliense*), but increases in bole diameter (56-66% gain). Crown volume increase was significantly greater with thinning for all species except *T. amazonia*, whose crown volume declined with or without thinning.
Discussion: Our data demonstrate the value of intermediate plantation thinning, even when delayed, to maintain plantation productivity of these native species and provision of timber. Variable responses among species appear to be linked with their ecophysiology.

Climate impact of using former arable land for biomass production in different bioenergy pathways in the transport sector

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Nguyen Le Truong

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Introduction: Today there exists around 400.000 hectare of unused agriculture land in Denmark which could be replanted and used for bioenergy applications or as carbon storage in form of forests. In this paper, we study the climate impact of using former arable land in Denmark for biomass production in different bioenergy pathways and technologies in the transport sector to mitigate climate change by substituting fossil motor fuels.
Method: To perform this kind of analysis a methodological framework is needed to accurately compare different energy systems and with the aim to minimize the net greenhouse gas emissions to the atmosphere and hence the climate impact. Therefore, we conduct system modeling in a life cycle perspective to understand the energy and climate implications of using different tree species which are producing different amounts of forest biomass on one unit land for bioenergy. Over a 240-year time horizon, we compare and contrast the time profiles of net biogenic and fossil carbon dioxide emissions, and cumulative radiative forcing as a proxy measurement of climate change effect.
Results: The results show that different species provide different amount of biomass in the same period which can use for different end-use energy services with different technologies.
Discussions: The aim of this study is to better understand the climate implications of using forest biomass from different tree species planted on arable land to replace fossil fuels in bio-motor fuel production and bioelectricity production in stand-alone plants.

Evaluating stand developmental trajectories for bottomland hardwood restoration efforts in the southeastern United States

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Introduction: Globally, ambitious efforts are being made to restore forests lost to deforestation and conversion to agriculture. In floodplain forests of the southeastern United States, afforestation programs have, over the last several decades, attempted to restore tens of thousands of hectares of bottomland hardwood forests on marginal agricultural land. This study evaluates structural and compositional development of young (<20 year-old) restoration plantings of different floodplain hardwood species (primarily oaks).

Methods: Measurement plots were established in sites across the Mississippi River floodplain to evaluate a range of soil types, species, and stand conditions. Measurements included natural recruitment, growth, bole, and crown characteristics. Performance was related to tree and stand-level characteristics, including diameter, crown height, basal area, composition, and stocking. A quantitative review of available literature was also undertaken to augment field measurements.

Results: Growth and survival vary widely across sites, and among species. Where growth and survival of planted oaks have been high, structural and compositional diversity has been slow to develop. Form and quality of planted trees generally improves as stocking increases, and with increasing compositional diversity provided by natural recruitment.

Discussion: While restoration of forest cover varies widely among sites, "successful" plantings of oak species have been slow to develop compositional diversity. Release or enrichment treatments may be needed to increase species diversity. The improved stem form associated with higher levels of natural recruitment provides additional support for the benefits of mixed-species approaches. These findings should improve restoration efforts, particularly as we seek to enhance landholder and ecosystem benefits.

We want to restore but today we can't: Bottlenecks for the restoration of natural forests in Southern Chile

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Introduction: International agreements (COP21) and the recently defined new Chilean Forestry Policy (2015-2035), represent a significant opportunity for forest restoration in the country and the region. However, the challenge to restore 100,000 to 500,000 ha by year 2035 mainly with native species seems hard to meet.
Methods: Here, we discuss the major bottlenecks that constrain forest restoration with native species in Chile.
Results: First, the country has the urgent need for a national strategic vision of forest restoration, which should consider different socio-ecological contexts, appropriate economic subsidies and flexible regulations that allow novel plantation designs. Second, a significant increase of the total national stock, diversity and quality of native seedlings available for forest restoration in Chilean nurseries is urgently needed. Third, current poor-quality seedlings of native species usually have low survival and growth rates in the field. High-quality seedlings plus adequate site selection and associated plantation techniques within an extensive network of forest restoration experiments would allow for monitoring in short- and long-term critical phases of plant growth. We already have evidence in Chile that by manipulating key environmental and micro-site factors it is possible to improve the survival and early performance of native species.
Discussion: Beyond experiments, forest restoration should be efficient to become massive. For that we need to overcome these bottlenecks. We need to start with applied research to translate forest restoration from a theoretical discipline to practice so as to achieve the forest restoration challenge for Chile and the region in the next decades.

Poster session

Thinning for deciduous related biodiversity in south boreal Sweden – reversed silviculture!

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Introduction: In Swedish production forests, an increased proportion of deciduous trees is often identified as a step to enhance biodiversity. Therefore some stands, particularly in boreal zone, are purposely managed to be dominated by deciduous trees, not for economic purpose, but to support species dependent on such trees. This is usually done by the removal of coniferous trees (thinning) from stands, with particular focus on the shade-tolerant Norway spruce (Picea abies).
Method: We surveyed a number of stands managed in this way in one of the "ekoparks" owned by the state forest company Sveaskog in south-central Sweden. In 291 sample plots located in 30 stands, all trees and stumps were measured and emerging shoots were counted 2-11 years after the thinning. The characteristics of the stands before and after thinning were compared in order to assess its initial effectiveness in enhancing deciduous component. We also registered the degree of browsing.
Results: Furthermore we related the observed regeneration of deciduous trees to a number of different environmental variables. New shoots were primarily aspen (Populus tremula) and birches (Betula sp.) which will most probably form new stands, however browsing pressure was high e.g. over 90% of the aspen shoots were browsed.
Discussion: We conclude that the initial development after thinning has been positive for the deciduous component and this conservation measure can be successful assuming that young trees can cope with high level of browsing.

Reforestation: a strategy to recover degraded lands in Hidalgo, Mexico

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Araceli Ventura
Ofelia Plascencia
Patricia Hernández
Gregorio Ángeles

Reforestation can be an important strategy for rehabilitating ecosystem structure and function. Our study objectives were to evaluate the effect of reforestation on structural components of forests, such as biomass, basal area, and understory plant diversity and functional diversity. To do this, three reforested areas of 5, 12, and 14 years old (R5, R12, and R14) and a reference site (SR) were sampled. In each condition eight circular plots of 400 m^2 were established to measure the tree total height and diameter at breast height. To evaluate the richness and abundance of species of shrubs and herbaceous plants, eight plots of 100 m^2(shrubs) and a 1 m^2 (herbaceous, nested) plot were established. Alpha and beta functional diversity indices were determined and functional plant types were characterized. The SR had the highest amount of biomass (25.3 Mg ha^{-1}); R12 and R14 had 12.2 and 14.1 Mg ha^{-1}, respectively. Across all treatments, we found a total of 44 species of vascular plants in the understory distributed among 42 genera and 34 families, with 90% native species. The highest species richness was found in R14 (29) followed by SR (24), and R14 had the highest values of diversity as well. According to Jaccard index, R5 had the greatest similarity (61%, i.e., lowest diversity), whereas the SR, R12, and R14 had values between 40-50%. We distinguished three plant functional types: 1) herbaceous annual, 2) succulents, and 3) evergreen shrubs. Our results demonstrate that rehabilitation of degraded lands through reforestation lead to an increase in biomass accumulation, richness and diversity.

How can my paper be useless for future meta-analysis on plant quality?

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Introduction: Advances on plant quality research require synthesize current knowledge and guide new research and practical applications. Abundant literature on the predictive ability of seedling functional attributes on post-planting performance has been produced over the last 70 years. However, the sometimes apparently contradictory results observed hamper the generalization of the accumulated knowledge on this topic. Statistical meta-analysis is a powerful and useful tool to quantitatively synthesize the information conveyed in the published studies on a particular topic. It allows identifying overall patterns and exploring the causes of variation. However, the inclusion of published works in meta-analyses requires a minimum quality standard of the reported data and information on the methodology used.
Methods: We performed a systematic literature review of published studies since 1950 to conduct a meta-analysis on the relationship between seedling size and field performance (growth and survival). We considered works reporting pre-planting size and post-planting performance, and examined information on plant cultivation techniques, plantation methodology and site characteristics.
Results: 306 studies were selected, of which nearly one third were discarded because essential data were not properly reported. In most cases, statistical dispersion parameters were not included. Information regarding field location, site preparation, plantation date, plantation density or previous land use was not reported in most of the selected studies.
Discussion: We present a guideline for reporting essential information from plant quality studies. Following the proposed recommendations would ensure that works meet the requirements to be included in future meta-analyses on this topic, increasing their utility for the wider forest restoration community.

The Survival of A 36 month-old Enrichment Planting under a Greened Slime Tailings In Tin Tailings Afforestation Centre, Bidor, Perak

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Introduction: An enrichment planting program of tropical rainforest species was carried under a 12 y-old *Hopea orodata* stand established on slime tailings.

Methods:
A 1.5 ha of the greened slime tailings had been enriched with 20 indigenous tree species. Ash tr eatment was applied to 50% of the planting. Survival counts were made annually.

Results: The survival of the enrichment species for both ash treated and control plot was at 97 to 98% at 12 months after planting. The survival of the planting was reduced from 91.8% to 74.9% from 24 months to 36 months after planting. Ash treated plots and control plot s had an average survival of 75.1±15.8% and 74.8±17.8%, respectively. Dipterocarps and non-dipterocarps had an average survival of 83.0±6.1% and 64.5 ±19.0%, respectively.

Discussion: Dipterocarps had higher survival than non-dipterocraps. *Shorea roxburghii* and *Shorea ovalis* had survival > 90%, both species are kno wn to be suitable for adapting in open conditions. Whereas, *Pentaspadon motleyi* had the high est survival for the non-dipterocarps. The effects of ash treatment didn't significantly affecting the survival of the rainf orest species. Mortality of the planting was mainly due to destruction of the seedlings by wild b oars.

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Natural Regeneration of A Greened Ex-tin Mine

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INTRODUCTION: Man-made mixed forest stands were established on an ex-tin mine at 17 years ago. A study on natural regeneration of the mixed stands was carried out.

METHODS:

A survey of natural regeneration on a 20 ha plot was carried out, the distribution of saplings m ore than 5 cm dbh were mapped using GPS. The species composition was determined and tree diversity index was calculated using Shannon Index.

RESULTS:

A total of 20 tree species was mapped and identified. Low regeneration was quantified at the o pen site where no trees were planted before, and even at the edge of the pool < 4m a.s.w.l. Hig h number of regeneration reached > 5cm dbh was found within 100 m from the edge of the pla nted forests. The Shannon Index (H) peaks at sand dune situated at 10 m a.s.w.l., similarly, the peak of maximum diversity possible (Hmax) of sand dune was ascertained at the same a.s.w.l., a nd declined to the lowest at 22 m a.s.w.l.

DISCUSSION: The man-made mixed species forests established on ex-tin mine witnesses the success of planting technologies and tending techniques in rehabilitation of degraded sites and sustainably maintained till this day. The natural regeneration including 2 0 species of lowland primary species and mature secondary forest species which were brought mainly by avian dispersal agents.

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Can we design production forests that encourage native restoration without limiting production?

Thomas Baker, Sue Baker, Greg Jordan, Robyn Scott, Rob Musk

In the wet eucalypt forest of Tasmania, traditional forestry practices such as clearfell burn and sow silviculture limit the capacity of the pre-harvest vegetation to recolonise. To combat this lack of regeneration capacity, new harvesting techniques have been developed that aim to maximise the ability of pre-disturbance species to survive and recolonise harvested sites. These techniques focus on retaining forest patches at local and landscape levels, thereby providing sources of recolonisation through retained propagule sources or enabling species to survive through the disturbance process. However, as timber production remains a key objective in these systems, there is interest in understanding how the retention forestry techniques impact growth of wood production species. This talk discusses work of two major projects established in the wet eucalypt forest of Tasmania. In particular we will discuss the mechanisms by which retained forests encourage the restoration of pre-harvest species and how distance to retained forest patches influence the regeneration capacity of pre-harvest forest species, in particular bryophytes, beetles and rainforest trees. In addition, we discuss wether harvested areas designed to encourage the regeneration, impede the growth and production of the major Eucalypt timber species.

Understanding forest and sustainable land use investment potential in developing countries; an "impact calculator" rapid assessment framework

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Mobilizing private sector investment in forests and sustainable land-use through public-private partnerships that demonstrate how companies, communities, smallholders and governments can work collaboratively to reduce deforestation is widely seen as critical in addressing the funding required to negate the drivers of deforestation and land degradation. Significant private sector funding is available to invest but there is a widely acknowledged deficit of bankable projects that deliver the required environmental, social and financial returns.
Many projects and initiatives exist that work with communities, forests and sustainable land-use but few have a clearly articulated investment proposition. Such projects deliver value and impact but in ways that are often difficult to compare and understand rapidly. Being able to quickly understand the potential impact of such projects in a scalable and robust manner is an important element of the investment mobilization process.
An "impact calculator" rapid assessment framework has been developed as a prototype to address this issue. The framework creates comparable projected impact profiles of projects and their potential investment. The framework uses information such as; project land-use area, land-use type, partnership profile, commodity or industry typologies, investment type and value, business maturity, location and jurisdiction.
We will present the framework and initial findings from over 50 projects and potential investment opportunities from across Africa and Indonesia. We will highlight opportunities for further development and testing and discuss the potential impact of such approaches in supporting more effective and rapid mobilization of private sector investment in forests and sustainable land-use.

Twenty year survivorship of tree seedlings in wind-created gaps in an upland hardwood forest in the eastern U.S.

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Introduction: We investigated advanced regeneration survivorship within and around wind-felled gaps created by Hurricane Opal (October 1995). We hypothesized that survivorship would increase along a linear distance gradient from the unaffected forest towards gap center.
Methods: We tagged 480 tree seedlings within 12 gaps May to July 1996. Seedlings were located along two perpendicular linear axes that intersected at gap centers and extended into the untreated forest. Tagged seedling survivorship was measured 5 times 1997-2016. Repeated measures survivorship models were parameterized for three soil moisture regimes. Survivorship was related to covariates representing variability in seedling microenvironments.
Results: Overall survivorship probability declined from 1997 (0.96) to 2016 (0.56). Survivorship decreased markedly after the fourth (2005) measurement- largely driven by overtopped seedling death at canopy closure on mesic and submesic sites.
All-sites model: Survivorship increased on a linear gradient from gap center into the unaffected forest. We therefor rejected our original hypothesis that survivorship would increase towards gap center.
Mesic-submesic (wet) and xeric-subxeric (dry) models: Survivorship was modeled as a function of categorical position of tagged seedlings: gap interior, perimeter, and exterior. Survivorship was greatest in exterior positions (the unaffected forest) in both models. However, the relationship of seedling survivorship to gap position was stronger in dry than in wet sites.
Discussion: Rapid growth of arborescent competitors after the hurricane reduced light available to tagged seedlings and drove-down survivorship rates. Competitor response was greater in gap interiors than in exterior sites and therefor survivorship was higher in gap exteriors. Gap "side light" provided sufficient photosynthetically active radiation (PAR) for the development of tagged seedling species rated intermediate in shade tolerance such as *Quercus spp.* up to approximately 30 meters from gap perimeters into the unaffected forest. Contrary findings between wet and dry site models can largely be attributed to differences in arborescent midcanopy and overstory development after the hurricane: canopies grew more rapidly in wet than in dry site gaps and reduced available PAR to levels approaching those found in gap exteriors- attenuating PAR and seedling survivorship gradients from gap center to exterior.

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Density of seedlings in natural and artificial regeneration of Scots pine (Pinus sylvestris L.)

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Introduction: The aim of the study was to assess how well natural regeneration of Scot pine could establish and grow in various soil preparation variants and compare it with artificial regeneration.
Method: Three types of soil preparation were used on the sample plots with natural regeneration: preparing by forest plow, wild boars rooting and control (without soil preparation). For the assessment of density of pine seedlings a method of transects was applied.
Results: The method of soil preparation determined the density of natural regeneration. Seedlings density was significantly higher on the plowed soil (6800 pcs/ha). The effectiveness of initiating of wild boars rooting by fall of maize should be assessed as low (density of seedlings 422 pcs/ha) and on the control plots the density was 866 pcs/ha. The density of seedlings in natural regeneration on plowed soil was higher than in artificial regeneration (6900 pcs/ha). There was no correlation between seedlings density and distance from the wall of forest stand.
Discussion: Other authors observed a much higher density of seedlings (Wolski, Robakowski 2008) in natural regeneration. It was more often observed reducing of seedlings density with increase of distance from the wall of the seedling stand (Korzeniewicz et al., 2016).
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Role of magpie (Pica pica) as a mobile link species for tree regeneration in Mediterranean agroecosystems

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Introduction: The magpie (*Pica pica* L.) is a scatter-hoarding corvid that may play a relevant role in dispersal of nut producing trees. However, the characteristics that determine habitat and microhabitat selection for caching the nuts, as well as the consequences for plant recruitment, are largely unknown.
Methods: We analyzed habitat selection by magpies for walnut caching in a Mediterranean agroecosystem. We manipulated experimentally the agroecosystem to create habitats that differed in grass cover, tree cover, and soil compaction. Seed dispersal was monitored with small transmitters inserted in the nuts. A sowing experiment was conducted to analyze the consequences of caching characteristics for seedling recruitment.
Results and Discussion: A total of 311 dispersed nuts were monitored, with dispersal distances reaching 442 m (mean = 55.4 m; median = 39.3 m). Most nuts (91.3%) were cached, whereas the remaining were consumed just after dispersal. Interestingly, the nuts cached were heavier than the consumed ones (11.88 g vs 10.95 g). Nut mass did not affect dispersal distance. Magpies similarly selected open habitat and wooden habitat. However, at a finer spatial scale, they clearly selected bare ground against areas with high grass cover. Most nuts were cached in soil with low compaction, where they could be buried. The sowing experiment showed that burial was critical for recruitment, with 32% of buried nuts germinating or emerging in spring versus 0% for nuts placed in the surface. Our results have implications for agroecosystem management to promote active or passive forest restoration mediated by this plant-animal interaction.

Comparison of East and West origin pine sowing results in Central part of Latvia

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Introduction: Latvia is famous for tall and straight *Pinus sylvestris*. Unfortunately pine regeneration becomes more complicated due to lack of precipitation during summer months on bare soils and browsing. Bare root or containerized seedlings are mostly used in anthropogenic forest regeneration in Latvia nowadays. Both methods have a high risk of damages in case of browsing and dry periods. Seedlings which come from nurseries are more lush than ones developed directly in sandy soil. Sowing of pine should be one of the solutions for decreasing costs for forest regeneration through high quality reproductive material and minimizing the risk of dieback in case of climate extremes and increased game population, when plants have lower survival rates and more seedlings are needed on site in the first years.
Method: Latvia has two reproductive material production regions - East and West. Seeds from both regions as well as locally sourced seeds were sown nine years ago on the border between both regions aiming to compare growth if seeds are sown on a forest site.
Results and discussion: Since pines from East regions have larger annual increments in the first years and the pines from Western regions are characterized by slower growth, similar results were recorded in eight year old trees height and diameters at breast height. If manually sown pines are growing in groups then pines from West and East regions have one dominant tree while reproductive material selected in the central part of Latvia typically have more balanced growth in groups.

Natural regeneration of Picea abies and other tree species after gap cuttings in southern boreal Scandinavia

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Introduction: Clearcutting and shelterwood are established harvest methods in southern Sweden. More irregular, selective cuttings are rarely applied. As natural regeneration dynamics without enrichment planting have barely been studied, natural regeneration after partial cuttings was examined in a heterogeneously structured forest to complement a similar regeneration study in another multi-layered pine-spruce forest (Drössler et al. 2017).
Method: In one stand, study plots with the treatments 'target diameter harvest', 'gap cutting' and 'no harvest' were established. Regeneration was measured on 900 subplots in 2012 and 2016. Seedling density, height and tree species proportion were recorded to evaluate overall density per treatment and species. In addition, the effect of soil scarification as sub-treatment on study plots was investigated.
Results: 2012, there was already sufficient regeneration established to regenerate the stand succesfully during the next 2-3 decades (2000 individuals/ha >50 cm plant height). Spruce dominated the regeneration (75%).
In 2016, the density increased to 5000 seedlings. In gaps, 7000 seedlings/ha were found, but also in non-harvested areas the number increased slightly (2700 individuals/ha).The proportion of spruce remained rather constant without management and with target diameter cutting. In gaps, its proportion decreased significantly to 25%.
Discussion: Without gaps, the next stand generation is expected to be dominated by spruce. Special measures or site conditions need to be considered to increase tree species diversity.

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Naïve rodent seed predator's attraction to the smell of acorns.

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Introduction: Direct seeding instead of planting nut-bearing trees such as oaks (Quercus sp.) may substantially reduce costs of regeneration. However, a major issue when sowing is the high predation of acorns by animals. Scatter hoarding rodents efficiently locate buried seeds using smell. The aim of the present study was to identify chemical compounds from acorns that may attract forest rodents and to study naïve rodent's attraction to acorns in order to better understand how to prevent rodents from locating tree seeds.

Method: Volatile compounds emanating from acorns were collected using dynamic headspace sampling and then analyzed using gas chromatography–mass spectrometry. To assess the olfactory preference to acorns in forest rodents we used a two choice Y-maze behavioral assay. Lab-bred bank voles' (*Myodes glareolus)* preference to acorns, a volatile extract and their standard diet was tested.

Results: In the behavioral assay, bank vole's which had never experienced acorns or the smell of acorns were as attracted to them as their laboratory diet. The volatile compounds emanating from acorns consisted of around 15 main compounds, where the majority belonged to the monoterpenes.

Discussion: Our results suggest that bank voles are either innately attracted to acorn smell or are able to generalize from odors of food they have experienced. Usually far from all compounds that emanates from food contributes to what animals smell. Many of the compounds we have identified are also present in oak leaves, and may therefore not be a good identifier of acorns.

Methods to improve the regeneration of Quercus brantii seedlings in Mediterranean oak forests

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Introduction: Quercus brantii is dominant species of Mediterranean area of Zagros forests in Iran that endangered by the lack of regeneration. The aim of this study was achieving to an efficient method of restoration using an integrative methods of bio-fertilizer recruitment, seedbed preparation and canopy cover.
Method: Acorns were sowed under canopy and in open space with three techniques of plantation consist of planting inside and outside of drainage holes and in narrow holes, either with or without PGPR native bacterium. Initial growth parameters of germination rate, stem length and leaf number were assessed after two month.
Results: Planting of acorns in narrow holes was most efficient technique with 55% germination rate and it decreased to half inside of drainage holes. Germination rate of acorns planted in soil heaps out of the drainage holes were extremely low (4%). Seeds sowed inside of drainage holes produced seedlings with 36% longer than other methods, but no significant differences were observed for leaves number in any treatments. Inoculation with bacteria or under shelter of mother trees had no significant effect on germination rate and growth of seedling at the beginning of growing season.
Discussion: Accumulation of leaf litters and dispersed trashes of forest floor in drainage holes partially diminished seed germination. Any judgment about the efficiency of inoculation and sheltering need to be consider at least at the end of growing season. Despite of low cost, applying narrow holes for sowing acorns could enhances germination rate and decrease the risk of seed predation.

Impacts of Hopea odorata Stand on Biomass Accumulation and Carbon Cycle in an Ex-tin Mine

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Introduction: Tin mining activities had propelled the socio-economic growth of Peninsular Malaysia since the late 19th century to early 20th century. These activities had completely altered the landscape of the mining sites leaving these areas desolate with little or no efforts of rehabilitation. The tailings are composed of sand, slime or sandy slime.
Method: This study is part of a rehabilitation effort and was conducted to estimate the carbon sequestration potential of a 7-year-old *Hopea odorata* stand grown on sand tailings. Six trees selected from a representative range of diameter at breast height (DBH) were cut and roots excavated. All tree components (stem, leaf, branch and root) were separated and weighed. Carbon (C) pools of the tree components, litter and soil (0-30cm) were calculated.
Results & Discussion: Soil total carbon (TC) decreased with increasing depth. Results from TC analysis indicated C stock was 12.73 ± 0.90 Mg/ha at 0-30 cm depth. Total above-ground stand biomass amounted to 42.99 Mg/ha estimated by the best statistical model used. If the total biomass at both sites was assumed to be 47% C, the aboveground C sequestered by *H. odorata* stand including forest floor litter would be 20.33 Mg/ha. Roots accounted for approximately 26% of total tree biomass with 51% C thus contributing 5.70 MgC/ha. The results indicate that soil and below-ground biomass also provide significant C pools besides tree biomass in a planted forest stand on a degraded ecosystem.

A Global Online Survey on Forest Adaptation and Restoration Under Global Change – Concept and First Results

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Introduction: Climatic and societal changes affect forest ecosystems and confront forest managers worldwide with the challenge to increase the adaptive capacity of forests. However, sound management decisions have to be information-based, therefore the compilation of expert knowledge on local experiences with forest adaptation and restoration from all parts of the world will form a profound basis for decisions on the local, regional, and international level.
Material & Methods: We present a novel online survey approach that gathers information on real world forest adaptation and restoration projects. This includes fundamental data on location, environmental- and forest conditions, management regimes, and actors. Furthermore, in-depth information on the targets, implementation, and success factors of the forest adaptation and restoration activities in the face of climate- and societal change will be gathered to form the basis for developing best practice approaches.
Results: Early results suggest that climate change is the most important underlying cause for the need of forest restoration/adaptation, while degradation, loss of ecosystem services and biodiversity as well as the vulnerability to diseases were important issues addressed by the activities. A variety of silvicultural measures were taken and with regards to species selection a preference of local provenances of native trees was found. The participants rated the activities as successful and good examples for other regions. This was enabled through forest management and a good cooperation between authorities and stakeholders.
Discussion: While some information has already been obtained a much higher number of participants is needed to make the survey a success.

Restoration of even-aged Norway spruce stands by direct seeding of silver fir - lessons learned from history

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Introduction: Regeneration by direct seeding has a long tradition in silvicultural management. The main application of the direct seeding of silver fir (*Abies alba* Mill.) today occurs in the context of the conversion of Norway spruce (*Picea abies* L.) stands in central Europe (Fischer et al. 2016). Although direct seeding is inspired by natural regeneration in many respects, tree planting is currently more commonly employed in forestry.

Method: An extensive historical review was undertaken to reveal the many facets associated with and the experiences of direct seeding gleaned through scientific experiments or based on forestry practice. A review of the historical development of the direct seeding of silver fir from its origins until the present day was carried out.

Results: The review showed that over the last century, techniques have been developed guaranteeing high seed quality, the optimisation of seed storage and suitable seedbed preparation. The main risks are associated with unpredictable climate conditions such as drought, the early loss of shelter trees, high levels of competition from ground vegetation and high browsing pressure.

Discussion: The importance of direct seeding has increased over the last two decades. Given the close-to-nature management objectives of most forest administrations in Europe, direct seeding should be developed as a management option.

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The use of exotic tree species in Serbia: What have we learned so far?

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Introduction: The use of exotic tree species in Serbia have a long tradition with various success. This paper offers a review on the history, present status and future perspective of exotic tree species used in Serbian reforestation/afforestation programs.
Method: Papers reporting exotic tree species in Serbia, published since 1920s are reviewed. The list of exotic tree species used in Serbian reforestation/afforestation programs is produced. For 10 most important exotic tree species tables and figures with results on productivity and distribution are made based on reviewed results.
Results: Only a small portion of over 500 introduced tree and shrub species cultivated in Serbia have a commercial value in forestry. Some of the exotic tree species become invasive and need to be controlled. The two most used species in forestry are black locust and hybrid poplar clones, both contributes more in annual volume increment in comparison to their portion in forest cover area.
Discussion: The strategic documents on Serbian forestry development encourage the use of native tree species in forest restoration programs, and there is a general negative perception on the use of exotic tree species in forestry. Considering increasing demand for wood products and predicted climate change, the introduction of new and appropriate exotic tree species will become more important. In the same time, the use of some exotic tree species already introduced need to be reconsidered and reinvented. Invasive species, which usually shows rapid growth in the early stages, should be tested for use in the SRC systems.

Appalachian Regional Reforestation Initiative, and the Forestry Reclamation Approach for successful reforestation of mined lands

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Introduction: 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 working to reforest mined lands in Appalachia since 2004.
Methods: Through an adaptive learning process, research scientists have studied productive forests on older mine sites, used those conclusions to conduct research on how best to establish forest vegetation on recent mines, and identified mine reclamation practices that result in successful reforestation.
Results: 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, a 5-step approach. Scientists and mine regulators, working collaboratively, have communicated the FRA to the coal industry and to regulatory enforcement personnel.
Discussion: 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 knowledge and practices exist and have been in practice for more than 10 years, we will discuss questions relating to successful mine land restoration over the longer term, including reforestation of previously reclaimed, poorly reclaimed and abandoned mine lands, along with application to other drastically disturbed lands.

Survival and growth of 1-0 Pinus echinata seedlings relative to planted and natural hardwoods for restoration

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Introduction: Growing concern about global climate change has renewed interest in restoring *Pinus echinata* in *Pinus-Quercus* forests to increase resiliency and heterogeneity. Establishing *Pinus echinata* across portions of its historical range has proven challenging due to shade intolerance, slow early growth, and poor competitive ability. Our objective was to determine the expected survival and growth rates of planted *Pinus echinata* relative to artificial and natural hardwoods and to identify barriers to restoration success.
Methods: We used data from two long-term studies in southeastern Missouri, USA, to examine the survival and growth of over 2000, 1-0 *Pinus echinata* seedlings as a function of understory competition and overstory density in artificially and naturally regenerated stands.
Results: Growth of planted 1-0 *Pinus echinata* exceeded that of planted 1-0 *Quercus alba* or *Quercus rubra* when grown in the open during a 20-year monitoring period. However, during the first 10 years, planted *Pinus echinata* had lower survival and growth where competing with natural *Quercus* and other hardwood regeneration originating from advance reproduction rather than as seedlings. Regression analysis indicated that survival and growth of 1-0 *Pinus echinata* in natural stands was further reduced by retaining a hardwood overstory.
Discussion: Planted *Pinus echinata* grows faster than planted *Quercus* in open stands with few other hardwood competitors. However, most *Pinus echinata* restorations occur in *Quercus*-mixed hardwood stands where large advance reproduction outcompetes planted *Pinus echinata* after harvesting. Although retaining a partial overstory reduces survival and growth, data show the importance of controlling understory competitors.

Salvage logging and free succession following windthrow offer opportunities for forest restoration in conifer plantations

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Storms are part of the natural disturbance regime in European forests, having large ecological and economic consequences. In this study we focused on factors influencing recovery processes, following a stand replacing wind throw in 1999.
We investigated even-aged, single species stands of *Picea abies* and *Picea sitchensis* in different ages. The experiment consisted of three sites, each having four blocks with three treatments, 1) non-intervention, 2) non-intervention after salvage logging, 3) salvage logging, with replanting of common silvicultural species. A split-plot design was set up for dividing treatments into fenced and unfenced plots. Tree growth, species, browsing, deadwood, ground cover vegetation, micro-topography and crown cover data were collected. We analyzed the overall recovery rate and composition in the different treatments 18 years after wind throw, and related this to pre-storm forest structures.
Preliminary results suggested that the non-salvaged treatment recovered faster than the salvaged treatment, especially for tree density and height. The replanted treatment showed the fastest recovery. Our results also suggested that pre-storm forest structure e.g. surviving trees and advanced regeneration may have a strong influence on the recovery rate and composition of the free succession treatments. Finally, our results showed that many new tree species colonized the free succession treatments. Therefore, forest management focusing on diverse forest structures that enhances ecosystem resilience i.e. surviving trees, advanced regeneration, combined with free succession after wind throw, may be viable extensive restoration options in conifer plantations. Such restoration efforts also provide a window of opportunity for restructuring the forest in a more diverse direction.

Natural regeneration development on forest stand rehabilitation in Estonia

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Silvicultural systems for timber production have caused fundamental changes in ecosystem structure and functions. Restoration is an important tool for enhancing conservation values in protected landscapes which is a key component for the development of sustainable land-management system. Restoration actions attempt to guide the trajectory toward desired targets more quickly than would occur spontaneously. Many protected areas have been used heavily, such that they lack elements and processes that are common for natural forest ecosystems. Knowledge of the structure and function of natural forests forms the necessary basis for forest restoration activities. Different restoration treatments such as gap cutting, deadwood input and gap cutting with over burning were implemented at eight nature protection areas in Estonia since 2000. The aim is the study was to examine natural regeneration on established sample plots and compare it to regeneration dynamics in strictly protected nature reserves. Restoration pre-treatment stands are often homogeneous even-aged monocultures on fertile sites. Rehabilitation treatments increase their structural heterogeneity and promote differentiation of microclimatic conditions. Abundance of natural regeneration was significantly different by treatments and by seedling species. The best effect on natural regeneration was on the gaps with over burning where the regeneration of Scots pine and silver birch was the most successful. The abundance of Norway spruce seedlings was the highest on the sample plots of strict nature reserves.

Two-phase restoration of forest by a nurse stand of silver birch on large calamity-originated clear-cuts

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Introduction: This article presents an alternative method of forest regeneration by a nurse stand (two-phase forest regeneration) on large clear-cuts or storm-damaged areas. Nurse stand dominated by pioneer tree species refines unfavourable climatic and soil conditions of clear-cut, reduces competitive forest weed and improves conditions for successive regeneration of target tree species.

Method: Soil, stand microclimate, spatial distribution, growth and health conditions of target tree species were assessed on the experimental plots under nurse stands (dominated by *Betula pendula*) and on the clear cuts.

Results: Nurse birch stand positively affects site and microclimatic conditions of large clear-cuts, the favourable effect raises with nurse stand duration. Distribution of the regeneration costs over time and profit from nurse stand biomass positively improve forest economy. The results of the experiments showed great growth potential of nurse stands.

Discussion: Management by two-phase restoration with nurse stand can make better temporal and spatial arrangement of the future forest stands on present calamite clear-cuts.

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Impact of biotic and abiotic pressure on regeneration in evergreen forests in the Western Ghats, India

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Introduction: Regeneration is the process of silvigenesis by which trees and forests survive over time (Bhuyan *et al*., 2003). The success or failure of regeneration of any species is governed by many factures, but there are very limited research has been carried out in the tropical wet evergreen forests particularly the biotic interferences such as grazing, cutting of trees, collection of litter, soil etc.

Methodology: The present study was carried out in the tropical wet evergreen forest of Western Ghats region of Karnataka, which constitutes nearly 15 per cent tropical forests of the country. Totally 88 regeneration plots of 5 m X 5 m plot dimension were laid 250 m interval with in the belt transacts of 1000m X 5 m. In each plot the disturbance parameter were recorded and assigned a score for each disturbance parameter to calculate the cumulative disturbance index for each plot

Results and Discussion: Results of the study clearly showed a decrease in trend of regenerates of tree species and a reverse trend was observed for shrub and climber species. The regeneration of deciduous elements also increased with increase in disturbance. Higher disturbance has severely affected the regeneration of threatened and endemic tree species, indicating there is an urgent need to plan for the appropriate measure to overcome the problem.

Susceptibility of chestnut plant to Dryocosmus kuriphilus at crown scale

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Introduction: To reduce Asian Chestnut Gall Wasp (ACGW) impact on *Castanea sativa* more attention must be paid on plant resilience and resistance mechanisms. Management strategies based on biocontrol by *Torymus sinensis* could be implemented by silvicultural practices.
Method: Plant resistance mechanisms to the ACGW were studied in Central Italy in an attacked chestnut orchard focusing on: the vegetative state of different portions of the crown, the preferential conditions for oviposition in the crown, and the damages assessment on developing shoots . 24 plants belonging to the same Marrone cultivar were sampled in order to assess susceptibility regardless of varietal differences. All nodes on 1152 shoots were analyzed considering exposure, shoot insertion height, light conditions and shoot length (as indicator of vegetative vigor) . We included variables indicative of: vegetative state, susceptibility to ACGW and damage intensity.
Results: A significant heterogeneity in terms of attack and damage was found at crown level. The preferential oviposition sites were the lowest part of the crown and the less vigorous and/or shaded shoots. The vigorous shoots were characterized by a lower incidence (about half) of the most severe types of damage, which reduced the growth of new vegetative organs and, therefore, new potential photosynthesis.
Discussion: According to our results, it is possible to enhance plant resistance by pruning. Pruning should be of medium intensity and aimed to increase the vigor and to enhance light conditions in order to sustain plant growth and fruit production despite the insect.

Restoration processes at line cutting sites in an even-aged plantation, Mt. Fuji, central Japan

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Introduction: In Japan, roles of some of the plantations have been changing from single function (i.e., producing timber) to multi (e.g. conserving biodiversity) (Nagaike 2015). As one of the methods to accomplish the object, restoring toward uneven-aged mixed forests from even-aged pure plantations has been discussing. In an even-aged plantation, I have investigated growth and survival for planted trees and natural regeneration at line cutting sites.
Method: I set a permanent plot in a *Abies veitchii* plantation stand. The stand age was 50 years old and the size of the plot was 1.06 ha, including 5 line cutting sites (10 m in width in each) to promote natural regeneration. At line cutting sites, planted broad-leaved (*Fagus crenata*, *Quercus crispula*, *Alunus hirsta*, *Cerasus jamasakura*, *Acer palmatum*) and naturally regenerated trees (height $\geq$ 30cm) were measured their height. The censuses were carried out in 2007 and 2016.
Results: In 2007, there were no naturally regenerated trees in the line cutting sites, but *Larix kaempferi* were successfully regenerated in 2016. Survivorship ratios of planted trees were different among species, in particular, *F. crenata* has high mortality.
Discussion: Since *L. kaempferi* which were pioneer and fast-growing species would inhibit the growth for planted trees, weeding for *L. kaempferi* may need to establish the mixed forests with various species.
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Establishment and initial growth of planted Scots pine and Norway spruce on low and high fertility sites in northern and southern Sweden

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Introduction: Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea Abies* L. Karst.) are the dominant tree species in Sweden. Even though the species have very different requirements, silvicultural measures applied at regeneration, such as site preparation methods, are often the same.
Method: A study was established with the two species where growth and survival was studied at four sites, one poor and one fertile site in northern respectively southern Sweden. The trials were established on forest land 2011 and 2012, and in order to create environments with different nitrogen availability, three different soil treatments were applied, being: i) control, ii) bare mineral soil and iii) turned over soil. The soil treatment plots were then split in half, where a fungicide was applied once in one of the two sub-plots.
Results: For Norway spruce, growth was significantly higher in the turned over soil treatment compared to the bare mineral soil treatment at all sites. Whereas, for Scots pine, the highest growth was found on the turned over soil treatment and the lowest growth on the control treatment. At the most fertile site in southern Sweden, no effects of either soil- or fungicide treatments could be found for Scots pine.
Discussion: This study shows a more rapid initial growth of Scots pine overall, a time-lag of the positive effect of the turned over soil treatment on poor sites, and that growth of Norway spruce is more negatively affected in environments with less availability of nitrogen.

Tropical forest restoration – a fungal-functional perspective
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Introduction: Maintaining and restoring functional tropical forests is a global issue. The knowledge base and practice of tropical forest restoration is, however, poorly developed, particularly regarding decomposer webs dominated by wood decaying fungi. Experience from temperate ecosystems suggests that the functioning of wood-decayer metapopulations in human-dominated tropical forest matrices is primarily affected by set-aside quality and substrate amounts and dynamics in restored forests. Yet, operational information for forest restoration should go beyond such basic knowledge: we need explicit landscape-level understanding of the potential and limits of restored stands in complementing set-asides, and we should account for the "invisible" processes of fungal dispersal and mycelial colonization of trees and stands.
Methods: We study the links between fungal patterns and processes with reclamation activities in two active bauxite mine areas in Brazil, Para; representing a combination of 'land-sparing' (fixed area designated as set-asides) and 'land-sharing' management (dynamics of extracted vs. restored sites). We perform measurements at three nested scales and along the full fungal life cycle: combining landscape scale fruit-body surveys (distribution of reproducing mycelia) with high throughput sequencing (HTS) based meta-barcoding of DNA from airborne samples (spore dispersal) and wood samples (mycelium establishment).
Results and discussion: In our presentation we will introduce our study system, and discuss its potential and limitations in linking the ecological aspects of wood-decay fungi with the management of degraded tropical forest matrix and, hence, pushing the boundaries of tropical restoration ecology.

Drought resistance of Pinus ponderosa seedlings in response to organic N vs inorganic N fertilization. Evaluating plant drought-tolerance techniques

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Introduction: Nitrogen (N) the main element controlling growth but also affect plant stress resistance. Studies on plant drought tolerance addressed the effect of N fertilization rate or inorganic N forms. However, plants are also able to use organic N, and its low metabolic cost would allow seedlings to improve traits such as drought tolerance. It is unknown the effect of organic N on seedling drought tolerance compared to other inorganic N forms. Furthermore, there are several methods to assess plant drought tolerance, but there is not a comparative study evaluating accuracy vs timeliness of each technique. The goals of this study are i) analyze whether the N form applied as fertilizer affects drought tolerance in *P. ponderosa* seedlings, and ii) compare methods for drought tolerance assessment in plants.
Method: One-year-old containerized seedlings will be fertilized with three N forms (NH_4^+, NO_3^-, and amino acids) for two months and then subjected to three drought levels (control, moderate and high). Drought-tolerance will be evaluated as i) predictive attributes carried out just after fertilization period (pressure-volume curves, membrane stability, residual transpiration); and ii) response attributes during/after the induced-drought period (changes in growth rate, photochemical efficiency, stomatal conductance, gas exchange, photosynthetic pigments, proline, non-structural carbohydrates).
Expected Results: The results of this study could help to disentangle the role of organic N nutrition on stress resistance. Additionally to improve our knowledge of seedling quality in *P. ponderosa* to establish a comparative framework across techniques for assessment plant drought tolerance.

Long-term oak regeneration dynamics in Sweden (1953-2015)

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Introduction: Oak dominated forests are decreasing worldwide and regeneration problems are often considered a major factor. In southern Sweden the standing volume of oak increased with more than 400% from 1923 to 2015, seemingly contradicting the general trend. However, this does not necessarily reflect oak regeneration success.
Method: We used the Swedish National Forest Inventory (NFI) to analyze changes in oak occurrence of different diameter classes from 1953 to 2015, with a main focus on oak saplings (>1.3 m tall and <10 cm dbh). We put these trends in relation to major population changes of the dominant browsing species (moose and roe deer) during the last 56 years. Furthermore, we investigated the impact of forest composition, forest density, and forestry actions on oak sapling occurrence.
Results: We found that all larger size classes of oak have increased in density since 1953, while oak saplings have decreased drastically since the beginning of the 1980's. The decrease is particularly pronounced within broadleaved forest types.
Discussion: We put forward three alternative hypotheses for the oak sapling decline. First, oak is a preferred species by browsers and increasing browser populations create high browsing pressure on small oaks. Second, the light demanding oak is negatively affected by increasing forest density. Third, oak is targeted by forestry actions such as precommercial thinning. This study contributes to a better understanding of the long-term regeneration dynamics of oak in Sweden and elsewhere.

The recreational value of forest: some case studies in Tuscany region

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Introduction: The maintenance and restoration of forest have been characterized by high costs but the only function of forest that generates income is the timber production. Due to the negative economic balance, a lot of areas are abandoned. At the same time, the other non-market functions related to forest (so called Ecosystem Services) are lost: one of these is represented by the recreational aspect of forest that plays an important role in contemporary society (Forest Europe, 2015).

Method: According with LIFE Project (LIFE14 ENV/IT/000514), 250 questionnaires have been performed with the aim of evaluating the recreational aspect of forest. Each interview has provided a willingness to pay (WTP) for maintenance of forests located in the Region of Tuscany. A price list method has been conducted using a monetary range of WTP up to 22 euros: analyzing the annual users of case study areas, this range is related to the amount per year required to compensate for a negative balance.

Results: Some case studies with different management approaches were examined: coppice, active conversion to high forest and natural evolution of forest. For each of these approaches, different WTP have been calculated.

Discussion: Taking into account the cost-effectiveness of forest restoration, this work aims to evaluate one of Ecosystem Services of forest. The accuracy of data is evaluated through classic statistical indicators and through Random Effect Utility Model that is able to analyze a dependent variable (WTP) with finite values.

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Nursery stock type and browse protection affect field performance of three temperate hardwood species planted onto reclaimed mine lands

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Introduction: Reforestation of reclaimed mine lands using scientifically based reclamation practices is critical to restoring ecosystems and associated services. Reclamation practices in the eastern U.S. generally rely upon bareroot seedlings with little or no animal browse protection. Alternative nursery stockypes offer potential to improve reclamation success, but little research has examined potential interactions of different nursery stocktypes with other silvicultural treatments.
Methods: We evaluated the effects of nursery stocktype (container vs. bareroot) and browse protection (using tree shelters) on *Quercus bicolor*, Q*uercus rubra*, and *Juglans nigra* planted seedling survival and growth in a split-plot, nested factorial design. The study was replicated at two variable mine reclamation sites (fenced to exclude deer) in southwestern Indiana, USA.
Results: After one year, survival was > 80% for all species with no difference between stocktypes. Container seedlings had greater height growth than bareroot stocktypes for *Q. rubra* and *J. nigra*, while *Q. bicolor* showed no stocktype differences by site. *Q. bicolor* had the greatest height growth regardless of treatment, except on one site where container seedlings of *Q. rubra* and *Q. bicolor* had similar height growth.
Discussion: Our results, showing greater height growth for container seedlings in two of three species (likely associated with increased stress resistance on these harsh sites), illustrates the importance of the target seedling concept in mine reclamation. We also found large differences in height growth among species, reflecting species differences in stress tolerance. High early survival is feasible in mine reclamation, particularly when sites are fenced to exclude deer.

Live and dead biomass C accumulation patterns after highly varying intensity disturbances in primary forest

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Introduction: Accurate estimations of changes in forest carbon (C) balance with time are essential for predicting future forest carbon balance and its part in global C cycle. While practical overall understanding of global forest C dynamics exists, some significant forest systems are not studied in sufficient detail, resulting in possible biases. Furthermore, effects of low and moderate intensity disturbance have received disproportionately little attention.
Method: In this study, we use an extensive database of primary uneven aged Norway spruce forests (*504 plots, 15'304 tree cores*) from the Carpathian Mountains, to explore in detail the essential patterns in live and dead wood C dynamics after highly varying severity disturbances.
Results: Live and deadwood C pools had different recovery patterns following disturbances, but total C accumulation was nearly linear after varying severity disturbances. There was no decline in biomass accumulation as predicted by classical theory. Instead, stands continued to accumulate C until the latest stages of stand development, until the next disturbance event. Importantly, the recovery of C was faster in stands that experienced a higher level of disturbance.
Discussion: We document a clear positive effect of increasing severity disturbance on forest C balance. This effect is driven by severity influence on stand structure. Namely, higher severity disturbances result more even size trees and stand with higher C pools. These last remaining primary forests are under threat of being harvested, which would result in significant release of C to the atmosphere and the post-harvest stands would not store comparable amounts of C.

Responses of soil microbial community composition and enzyme activities to land-use change in the Eastern Tibetan Plateau, China

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Introduction: Due to commercial logging, old-growth forests (OF) dominated by firs were deforested and replaced by natural secondary forests (SF), plantation forests (PF), or grass lands (GL) in the subalpine regions. This study aimed to assess effects of land-use on soil physicochemical characteristics, microbial community composition, and extracellular enzyme activities.
Method: Soil microbial biomass and microbial community composition were determined by phospholipid fatty acid method. The function of microbial communities was assessed by analyzing the activities of β-glucosidase, N-acetylglucosaminidase, and polyphenoloxidase.
Results: Soil physicochemical characteristics varied significantly across land-use types. Land-use significantly affected the relative abundance of anaerobic bacteria, actinobacteria, saprotrophic and ectomycorrhizal (SEM) fungi. Soil organic carbon and total phosphorus were significantly and positively correlated with the relative abundance of anaerobic bacteria, arbuscular mycorrhizal fungi, and SEM fungi. While C:P ratio had negative association with the relative abundance of anaerobic bacteria and SEM fungi. Land-use had a marked impact on total microbial biomass, β-glucosidase and polyphenoloxidase activities.
Discussion: Land-use change had significant impacts on the structure and function of soil microbial communities in subalpine regions. OF and SF with fertile soils favoured highly total microbial biomass, anaerobic bacteria and SEM fungal communities, and β-glucosidase activities, whilst less fertile GL soil favoured highly polyphenoloxidase activities. Our work implies that changes in microbial community composition and microbial enzyme activities are likely to have subsequent impacts on nutrient cycling and C storage in these ecosystems.
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Successional dynamics of community structure and species diversity after clear-cutting of Abies faxoniana forest stands

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Introduction: In order to clarify the restoration processes after clear-cutting of the sub-alpine *Abies faxoniana* forest stands in southwestern China, dynamics of community structure and species diversity at five successional stages (10 years, 20 years, 30 years, 40 years, and 50 years) were studied.
Method: Species composition, number, average height, and canopy closure (coverage) were recorded in the five stages. Tree species distribution pattern and biodiversity indices of the stages were calculated respectively.
Results: Natural secondary forests were characterized by *Betula albo-sinensis*, *Betula platyphylla,* and *A. faxoniana*. Size-classes of trees in the successional stages of 20-50 years showed reverse *J*-shaped distributions. The five stages could be classified into three types, which were *Rubus* and *Rosa* shrubs, *Betula* broad-leaved forests and conifer and broadleaf mixed forests, by the importance value of dominant species. Shannon-Wiener diversity indices of arbor and shrub layer species increased while the index of herb layer species decreased with succession time. Pielou Evenness indices of the species in all three layers increased with succession time.
Discussion: Light-demanding pioneer tree species such as *B. albo-sinensis,* which regenerated rapidly after logging, was being replaced by shade tolerant tree species such as *A. faxoniana* at later successional stages due to increasing canopy closure and competitive advantages. It means that the forests are returning to old growth forest in this area.

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The non-toxic wax as feeding deterrent for adults of the large pine weevil Hylobius abietis (L.)

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Introduction: The large pine weevil, *Hylobius abietis* (L.) is the major insect pest species affecting reforestation in Europe. The adults of pine weevils feed on the stem bark of conifer transplants, often killing them or damaging them severely. Seedlings can be protected using various strategies. The use of physical barriers (wax, glue, latex) as an alternative to synthetic insecticides has increased in recent years in the Nordic and Baltic countries as well as in Estonia. The aim of the study was to test the effects of KVAAE wax (Norsk Wax AS, Norway) on the behaviour of the large pine weevil in laboratory conditions. The aim of current research was to determine the wax influence to the *H. abietis* feeding activity and toxicity in different host plants (Norway spruce, Scots pine, Siberian fir, European larch).
Materials & methods: The weevils feeding area was estimated after 24, 48 and 72 h in choice-feeding tests. An automated video tracking, Ethovision XT 11 (Noldus, The Netherlands), was used to record and analyze the movement of insects.
Results: The KVAAE wax acted as significant feeding deterrent for the adult pine weevils in choice-feeding tests. Wax ticknesses (0.6 mm, 1.2 mm) depressed entirely the feeding (AFI=1,0) of the specimens of both sexes during 72 hours on the treated twigs. Wax was not toxic and didnt influence the feeding behaviour of weevils.
Conclusions: According to laboratory tests KVAAE wax is a strong feeding deterrent on *H. abietis*. The study was supported by the projects: T12115MIMK, T150031MIMK, IUT 36-2.

Ageing of Faidherbia albida (Del. A. Chev) trees threatens the persistence of a climate-smart production system in the Central Rift Valley of Ethiopia

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Introduction: Scattered *Faidherbia albida* trees, provide multiple ecological and production benefits across fragile ecosystems of the Sahel. Sustainable conservation of this species requires comprehensive understanding of its regeneration and population dynamics.
Methods: *Faidherbia albida* seeds were planted on experimental plots within farmers' fields, which were exposed to combinations of grazing and ploughing treatments. In addition, 66 permanent plots were marked scattered randomly over an area of 562.5 ha. Using a dynamic modeling approach we explored major bottlenecks for regeneration and predicted trends in population.
Results: Density of *F. albida* was sparse for all population stages – 4.2 ha^{-1} of adults and 1.4 ha^{-1} of all juveliles. The first two months of dry seasoncaused 73–76% seedling mortality. Season-long aftermath grazing caused significantly greater seedling mortality. This caused densities of adults, seedlings, and saplings to decline by 1.2%, 51.3%, and 63.2%, respectively. Currently, only 48 % of the population was younger than 42 years and density will decline to one tree per hectare within the next 60 years with current management.
Discussions: Our results showed that the limited seed source is the main constraint for the sustainability of *F. albida* population in the long run, although short-term management practices could slow the rate of population decline. Current population age distribution of *F. albida* suggests failure in population recruitment. As the population decline threatens the capacity of the system to adapt to climate change, payment for ecosystem services that would encourage farmers to change pruning practice would ensure seed production, hence averting the population decline.

Recovery of a boreal carabid (Coleoptera: Carabidae) fauna 15 years after variable retention harvest

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Carabid beetles (ground beetles) are widely used as bioindicators to evaluate faunal responses to disturbance. Using un-harvested stands as controls, we examined the temporal (pre-harvest to 15 yrs post-harvest) effects of increasing initial harvest intensities (clear-cut, 10, 20, 50 and 75% green tree retention) on carabid assemblages in four cover types of boreal mixedwood forest in the context of the EMEND (Ecosystem Management Emulating Natural Disturbance) experiment in NW Alberta, Canada. Temporal fluctuation of species over the 15-year post-harvest period was greater in harvested compartments than in the controls. Carabid assemblages responded to harvest intensity, with assemblages in compartments with higher retention generally more similar in species composition to uncut controls than in compartments with lower retention. Recovery of carabid assemblages toward pre-harvest conditions was evident 15-yrs post-harvest, but extent of recovery differed among cover types. Carabid assemblages in compartments with initially high deciduous composition converged closely to pre-harvest beetle composition as defined by unharvested controls after 15 yrs. In contrast, assemblages in stands with significant conifer components moved steadily away from their pre-harvest conditions in their first decade and then became more similar to those of deciduous compartments. Thus, we conclude that conifer-associated assemblages are less resistant and resilient to harvesting. Although carabid assemblages of our spruce stands showed evidence of recovery by 15 yrs post-harvest, retention harvest altered them significantly and recovery of biodiversity will clearly be a long-term process connected to forest succession. This then requires management consideration.

Success of forest regeneration and soil preparation method

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The aim of the research is to develop, approbate and prepare for implementation innovative planning solutions, effective technologies and forest growing regimes in order to facilitate productive, qualitative and healthy stand development. Main activity for first year were "*Soil preparation method (mounds, furrows) effect on the quality of juvenile stands on organic soils and wet mineral soils".* Measurements were carried out during June - July in the forests on drained organic soils (22 sites), drained mineral soils (26 sites) and wet mineral soils (20 sites), where forest regeneration was carried out one to three years before, by planting conifers in mounds or furrows. Establishment of conifer seedlings was good, the only problem being browsing. It was found that differences in seedling height is not so important, but new finding, is that roots are not directed towards a particular cardinal direction on mounds. Root systems of pine and spruce seedlings planted one year ago were measured, and it was concluded that saplings are forming longer roots with bigger surface area, when planted on mounds, yet the root volume varies. Seedlings planted in furrows formed two-sided root system, parallel the furrow. Trees planted in mounds developed *"heavier"* and deeper central root systems, that expanded evenly and three years after planting had grown deeper than the mounds. Unlike the northern countries, in Latvia when soil preparation is carried out with excavators, main advantage is that excavating provides a micro-regulation of the water regime in soils. Only limiting factor to use mounding is costs.

Restoration of maritime forests in the coastal southeastern United States: evaluating limiting factors to *Quercus virginiana* regeneration

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Introduction: Maritime forests along the U.S. Southern Atlantic Coast are dominated by *Quercus virginiana,* live oak. These forests have been heavily impacted, however, due to conversion to agriculture and pine plantations. Pine beetle outbreaks have led to clearcut salvage of abandoned pine plantations, providing the opportunity to restore maritime forest. The aim of this study is to evaluate the influence of key limiting factors, herbivory and vegetation competition, in determining regeneration success of live oak.
Methods: One-year-old bareroot live oak seedlings were planted at clearcut sites in Coastal Georgia, USA using a split-plot experimental design, with herbivory (fenced and not fenced) and vegetation control (0, 1, and 2 yr competition removal) as independent variables. Seedling survival and growth were monitored.
Results: Overall survival was 64% after one year, with no significant difference between the treatments. There was a significant interaction between herbivory and vegetation control treatments for seedling height, diameter, and crown width: significantly greater mean values occurred in fenced plots with vegetation control.
Discussion: Our preliminary results indicate the importance of controlling herbivory, as fencing significantly improved seedling growth. While survival did not vary across treatments during the first growing season, this may change in subsequent years once the impact of herbivory and vegetation control compounds. Results from this experiment are essential toward developing prescriptions that are likely to promote live oak restoration along the southeastern coast of the United States and may have implications to maritime forest restoration practices in other regions.

Forest disturbance in a conservation area – dynamics of a bark beetle population after a severe storm

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Introduction: The European spruce bark beetle (*Ips typographus* L.) is causing serious damage after storms. In 2010, destructive storm in Finland felled down remarkable amount of Norway spruce. Our objective was to analyse storm-induced population development of *I. typographus* in a forest conservation area.

Method: We evaluated the colonization success of the bark beetle using stem analysis in three subsequent years. Wind-felled trees were sampled in storm gaps or in felled stands. Bark samples with egg galleries were taken from a trunk, to evaluate colonization success and reproduction.

Results: The population density of *I. typographus* was highest two years after the storm. In the second and third year, gallery densities indicating risk for outbreak levels were exceeded.

Discussion: For adaptation and mitigation forest ecosystems to increasing threat, it is important to understand the interaction between climatic drivers and disturbances. Risk modelling should be integrated to future forest management.

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Enzyme activity of the forest soil within damaged forest ecosystem of the silver fir forest with hard fern

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Introduction: Tree dieback changes microclimate and microbiological activity of the soil. The aim of this research was to determine differences in microclimate and soil enzyme activity in forest gap and forest stand.
Method: The research was done in forest gaps of fir forest with hard fern and in forest stands. Measured microclimate elements were air temperature, soil temperature, relative air humidity and volumetric soil humidity. At a depth of 10 cm were taken soil samples to determine dehydrogenase and soil proteolytic activity.
Results: No significant differences in chemical characteristics and enzyme activity were found between soils of forest gaps and forest stands. Air and soil temperature as well as soil characteristics had significant effect on enzyme activity. Increase of the organic matter, nitrogen, humus and carbon in the soil resulted increased enzyme activity of the forest soils. The highest correlations were found for forest soils proteolytic activity.
Discussion: Due to insignificant changes of soil chemical characteristics, in analyzed experimental plots differences in soil enzyme activity were not significant. These can be attributed also to the fact that forest gap is only four years old and relatively good rejuvenated with deciduous species. Seasonal changes of soil enzyme activity were correlated with seasonal fluctuations of abiotic factors like temperature and amount of available water. Dehydrogenase and proteolytic activity significantly were depended on microclimate. Significant decrease of soil enzyme activity in forest gap was not found in this research. The highest soil enzyme activity was at a beginning of the vegetation period.

The effect of soil management and seedling protection on *Nothofagus pumilio* establishment on disturbed sites

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Nothofagus forests in the Chilean Southern Patagonia were burnt in the past for clearing areas for extensive livestock breeding. Limited soil moisture conditions, wind speed, and radiation intensity limit the establishment of *Nothofagus* seedlings. As part of compensation plans, mine reclamation efforts require active reforestation to restore mixed *Nothofagus* forests. On a legacy meadow site, grazed by livestock on Riesco Island Southern Chilean Patagonia, we compared the establishment success of *Nothofagus pumilio* seedlings on replicated 1300 m^2 study plots under different management options: (1) direct planting in undisturbed soil and (2) planting on a deep layer of replaced topsoil. In both study plots, seedlings were planted unprotected and protected from wind and radiation by four different types of shelters: shade nets, irregular log piles, white polypropylene shelters, and woody branches. Seedlings survival and growth performance patterns were evaluated for three growing seasons. Site conditions were better in plots with replaced topsoil. The influence of seedling shelters was significant on growth and physiological response of seedlings directly planted in undisturbed soils and on unprotected seedlings planted in replaced topsoil. Seedling mortality was close to 70% in all the treatments in the meadows, indicating that vegetation competition and soil compaction create unsuitable conditions for reforestation. Our results contribute to the development of more specific recommendations for *Nothofagus* forest reclamation and the development of an integrative restoration plan for highly disturbed ecosystems in Southern Patagonia

Effect of in situ light x soil N resource interaction on *Quercus petraea* seedlings mixed-grown with *Molinia caerulea*

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Introduction: Availability of aerial and soil resources in oak forests is likely to change in the near future: wood harvest will increase to fulfill biomass demand and atmospheric N deposition is still high. Accordingly, oak seedlings will benefit from a larger availability of both incoming irradiance and soil inorganic N (N_i) amounts. Such changes may also favor graminoids, jeopardizing oak regeneration.
Methods: Along an *in situ* light gradient, 60 1-year old oak seedlings were planted. Effects of *M. caerulea* and N fertilization were tested by hand-weeding and applying 90 kg inorganic $N.ha^{-1}$. Seedling growth as well as tracking of ^{15}N fate was monitored and seedlings were harvested in autumn 2015 after one growing season.
Results: Tree growth increases along light gradient. Neither presence of *M. caerulea* nor N fertilization has any effect on oak growth. Under high irradiance, ^{15}N was preferentially allocated to leaves instead of stem. Eventually, only growth and N allocation were larger in fine roots when no N fertilization was applied or in mixture.
Discussion: Growth seedlings was positively responsive to light but not to changes in soil inorganic N resources due to presence of *M. caerulea* and/or N fertilization. Better growth might result from an optimized N allocation toward leaves. Fine roots biomass positively responded to N soil limitation, supporting foraging strategy. Nevertheless, lack of N resource due to biotic competition would promote graminoids uprooting in forest management practice to ensure a high success of regeneration.

Ecological functions of old admixed oak trees in the restoration of Scots pine monocultures
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Introduction: The admixture of old sessile oak (*Quercus petraea* [Matt] Liebl.) trees is a typical characteristic of the pure, even-aged Scots pine (*Pinus sylvestris* L.) forests that predominate in the north-east German lowlands. Little is known about the spatial and temporal ecological effects of admixed oaks with respect to the fauna and flora.
Method: The study area was a pine forest of approx. 3 ha with 31 admixed oak trees. All stem positions and individual tree traits were measured. Pitfall traps were established on a grid to collect carabid beetles and the ground vegetation cover, litter and pH value sampled. The toroidal shift test was applied for the subsequent bivariate point pattern analysis of oaks and beetles (Wagner et al. 2016).
Results: Gender and development stage specific spatial patterns were observed for the carabid beetle species. Correlations between the oak trees and the carabid beetles, vegetation and litter were spatially limited. The use of temporal niches by carabid species, and their developmental stages, could be demonstrated.
Discussion: The effects of single-tree admixtures within forests on the spatial patterns of carabid beetles can be shown using point pattern analysis. Based on the results obtained, the authors conclude that the strength of the ecological effects of oak trees on carabid beetles would increase given connectivity within this pine-oak habitat.
References:
Wagner S, Wehnert A, Wong KY, Stoyan D 2016. Discovering interaction between oaks and carabid beetles on a local scale by point pattern analysis. iForest 9: 618-625.

Supplying trees in an era of uncertainty: Challenges faced by the forest nursery sector in Great Britain

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Introduction: Continuing and emerging threats to forest health such as climate change, pests and diseases are causing concern that woodland in Britain lacks resilience to an uncertain future. There is current interest in re-evaluating the choices of planting stock used in woodland creation to increase the adaptive capacity of forests, for instance by sourcing seed from further south. However, the practical and economic implications of changing policies have been largely overlooked, notably, the commercial supply of forest plants and seed.
Methods: Using trade records and results from qualitative interviews with practitioners involved in the plant and seed supply chain in Britain, I will highlight common practical and economic bottlenecks in the supply of locally sourced seed and domestically produced planting stock for native woodland creation and discuss whether these difficulties preclude policy change.
Results: The survey shows that the supply of healthy domestically produced plants for woodland creation is incompatible with current short-term forestry grant cycles and that this has negative impacts upon domestic biosecurity and genetic resource management.
Discussion: There is need for wider recognition of the idiosyncrasies of commercial tree seedling production which requires managers, suppliers and policy makers to work together, especially in an era of uncertainty and deregulation.

Dieback of mother trees and environmental influence on initial seedling growth in Quercus brantii Lindl.

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Introduction: Reforestation success is important challenge in Mediterranean climate. Seedling traits may be subject to maternal and common environmental effects of the mother tree. Khaeiz protected area of Zagros forest showed an extensive dieback by Breneria quercinia bacteria in Kohgiluye and Boyerahmad province of Iran.
Method: Khaeiz protected area of Zagros forest was selected as a case study to investigate the impact of Oak dieback and topographic position on Oak seedlings growth. Therefore, Acorns were collected from 34 mother trees on the basis of declined affected (0-10% healthy, 10-30% medium and ≥30% severe) and different physiography (altitude, aspect and slope). Then seeds were planted in forest and germination and growth of seedlings were measured before and after dry season (June and September).
Results: Results showed that seeds collected from severe declined mother tress have smaller weight, size and germination than other two classes. Also height, diameter and leaf number of seedlings in two time (June and September) showed negative significantly correlation with declined percentage of mother trees. Relation between Altitude and slope was not significant for any growth parameters. But seedling growth were strongly influenced by aspect, as that, seedlings from mother trees of north aspect were larger that south aspect.
Discussion: Due to long dry season of this study area and climate change, collection of seeds from better condition of forest like north aspect and healthier mother trees can improve germination and growth of seedlings in reforestation.

Program Post-conference tour - Friday 15 September (Sweden and Denmark)

08.00 – Departure Lund (Conference venue AF Borgen)

08.45 – 10.45 **Trolleholms Gods AB, Sweden** (http://trolleholmsgods.se/)
Host: former director Esben Møller Madsen

- Forest Landscape Restoration at privately owned property
- Forest and landscape history
- Afforestation by direct seeding of oaks including red oak
- Use of native and non-native species in forestry
- The landscape perspectives and aesthetics in relation to the local society, the cultural landscape, buildings and houses
- Refreshments before departure.

12.45 – **Arrival Særløse – Nature Agency West Zealand, Denmark (State forest service)**
Host: Forester Hans Jessen

- Lunch

13.15 – **Program start**
- Forest and landscape history – from heathland to rich deciduous forest
- Mixed broadleaved/conifer forests
- Native and non-native species managed in to close-to-nature forestry
- Forest development types
- Goal oriented forest management – integration and/or separation of functions?

14.30 – **Allendelille fredskov – The Danish Nature Foundation**
Hosts: Forest Policy Advisor Nora Skjernaa Hansen (Danish Society for Nature Conservation) and Forester Leif Lauridsen (HedeDanmark)

- Managing for habitats and biodiversity
- Historical management to support open forest landscape habitats
- Engagement of volunteers

15.45 – End of program – departure for the Copenhagen Airport, Denmark – arrival at 17.00

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