# SERE 2018 - BOOK OF ABSTRACTS

**Keynote**

**K-01**

**Land Degradation Neutrality: A framework for optimizing restoration in the era of environmental change**
Barron Joseph Orr
United Nations Convention to Combat Desertification (UNCCD), BONN, Germany

Restoration under conditions of environmental change requires some fundamental changes in how we address land degradation. Despite the major advances in the “how” of ecological restoration, we are failing to keep pace with new land degradation. While the direct drivers of concern are well known, the reality today is that fixing land degradation location by location is not enough when consumption in one part of the world is influencing land and people in another. When we consider that the total of all land-based natural capital is limited, it is more important than ever that we do the right thing in the right place at the right scale, and work together to optimize mutual outcomes for present and future generations. This requires a framework that demands the identification of the optimal mix of interventions to avoid, reduce and reverse land degradation across the landscape as well at the capacity to consider the inevitable tradeoffs which come from multiple demands on land. Land Degradation Neutrality (LDN) provides such a framework. The goal of LDN is to maintain or enhance land-based natural capital, and its associated ecosystem services such as provision of food and regulation of water and climate, while enhancing the resilience of the communities that depend on the land. The mechanism for neutrality in LDN involves projecting new degradation so that it can be avoided, and in cases where it cannot, counterbalancing it with efforts to reverse past degradation. This simultaneous consideration of potential losses and planned gains requires an integrated approach to land use planning and management that is central to effective ecological restoration. The momentum behind LDN represents a tremendous opportunity to the ecological restoration community: LDN is a major plank in the global 2030 Agenda for Sustainable Development and 116 countries have committed to set targets.

**K-02**

**Worlds apart, yet alike: restoration for improved livelihoods and climate change mitigation across the Earth**
Hafdis Hanna Aegisdottir
United Nations University Land Restoration Training Programme, REYKJAVIK, Iceland

Over the millennia, humans have exploited nature for their own good. This has increasingly led to degradation and destruction of natural habitat and, in extreme situations, collapsed ecosystems and civilizations. Now, early in the 21st century, this is ever more a challenge as our planet is facing environmental changes on a scale that humankind has never encountered before. Land degradation, soil erosion, loss of biodiversity and global climatic change are among the major challenges that must be confronted in order to secure a sustainable future for life on earth. In diverse countries all over our planet, habitat destruction, overgrazing and overexploitation are a reality. Although situations differ between locations and environments, the processes and principles of land degradation, restoration of degraded land and sustainable land management are strikingly similar.
In this keynote lecture, I will discuss the commonalities in restoring ecological function and biodiversity to degraded landscapes across different biomes for improved livelihoods and climate change mitigation. I will share experiences from the United Nations University Land Restoration Training Programme, in which professionals from Sub-Saharan Africa and Central Asia receive training on restoration issues. The Programme is built on the century long experience within Iceland on combating land degradation and restoring degraded land. I will give examples from around the world of inspirational people, that are committed to combating land degradation, promoting sustainable land management and restoring degraded lands in their respective regions. Lastly, I will explore how humanity can gain from these common experiences, and how they can guide us towards working together for sustainability and preservation of our planet.

**K-03**

**Hipsters of Nature: raising awareness about environmental issues through the arts**
Beatrice Dossah[1], Ásthildur Jónsdóttir[2], Ellen Gunnarsdottir[2]
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Plastic pollution is a major environmental issue in Ghana. Plastic waste blocks drainage channels causing flooding , it destroys the livelihood of fishermen and poisons farm animals mistaking plastic for food.

Four years ago, I launched Hipsters of Nature, a Ghanaian NGO that uses innovative ways to reconnect the youth to nature and encourage them to take action against plastic pollution. We beleive that the younger generation would do

more for the environment, if only environmental issues are brought to them in a pedagogical and interesting way. Music, dance and fashion are part of everyday life in Ghana. Members of Hipsters of Nature are leveraging their artistic talent to educate on plastic pollution and unleash positive behaviours towards the environment. The group frequently collaborates with diverse community of artists, art festivals, schools, NGOs and eco- hotels to organize events mixing enterainment, educative workshops and concrete environmental actions such as beach cleaning. The presentation will show case excerpts of a research I conducted as a fellow at the UN University Land Restoration Training Programme in Iceland with illustrations from my experience with Hipsters of Nature. One of the recommendations of the research was that ecologists and artists should collaborate to efficiently communicate environmental issues to the civil society

**K-04**

**Ecological restoration as management tool for protection of biodiversity with growing tourism and climate change?**

Dagmar Hagen
Norwegian Institute for Nature Research, -, Norway

Tourism is increasing in the North, observed as increased number of visitors, new activities, new sites, longer seasons, and involving new groups of tourists and more diverse operators. Tourism is one component of the total pressure on nature and social values in Northern areas, together with industrial development, pollution, invasive species, over-harvesting and climate change. The different types of pressure interact and causes cumulative impact on nature and local communities. This diversity complicates the management of biodiversity when tourism is increasing and expanding. This presentation will put focus on tourism and its interaction with climate change, and how the knowledge and experience from ecological restoration can contribute to minimize, mitigate and restore potential impact on biodiversity and ecosystems.
Initially, tourism and tourists will be elaborated, with a Northern perspective and focus on nature tourism. The effect from tourism on a community or a site can be negative, neutral or positive, and often links to who, how many, when and how tourism is run. When rapid changes happen, the management system often “runs behind” trying to restrict and hamper commercial interests and explain lost battles. An alternative strategy is to be proactive and set the terms. This call for active management and will need a rich toolbox!
Ecological restoration is one such tool than can be further developed for improved management of tourism in nature areas. Ecological restoration can provide sensitivity assessment and describe the potential for mitigation, can give scientific input to visitor guidelines and management plans, can prepare and mitigate selected locations, and restore disturbed sites. The presentation will also show other traditional and new management tools that can support and improve protection of biodiversity and nature values in popular and upcoming tourism destinations. I will demonstrate how the available toolbox and the management opportunities should set the premises for what type and how activities can take place. Ecological restoration can be one contribution towards a more common understanding of sustainability within the tourist industry and the management of biodiversity.

**K-05**

**'Disturbance, resilience, evolution, restoration'**

Donald Falk
University of Arizona, -, United States of America

Assumptions of climatic and ecological equilibrium are likely to be justifiably suspect, particularly in periods of rapid change in the Earth system such as the Anthropocene. In addition to background variability, disturbances are transient processes that alter the distribution of mass and energy in ecological systems, often triggering significant and persistent demographic and functional change. We will examine interlocking areas of knowledge relevant to understanding how ecological systems may respond to disturbance regimes in a period of rapid climate change, and how this affects the science and practice of ecological restoration. First, we deconstruct the concept of disturbance itself, examining biotic and abiotic components of a variety of processes and showing the role of disturbance as a multiplier and accelerator of change driven by climate variation acting alone. Second, we decompose ecological responses to disturbance across a spectrum from persistence and recovery to system reorganization, and introduce a theorem of resilience. We also examine ecological disturbance from an evolutionary perspective, distinguishing organism adaption to independent disturbance events from cases in which organisms are active participants, suggesting that some disturbance regimes may be regulated at least in part by natural selection. Finally, we return to the central question of how ecological restoration can adapt to the formidable challenges in a rapidly changing world.

**K-06**

**Offsetting carbon and baking habitats: Can markets be the key for restoring nature?**

Erik Gómez-Baggethun
Norwegian University of Life Sciences (NMBU), -, Norway

Despite decades of environmental policy, ecosystems and biodiversity keep declining worldwide. In the name of

pragmatism and urgency, scientists are increasingly endorsing economic valuation and market-based instruments in the hope of developing more effective restoration strategies that better reflects dominant political and economic views. The market approach in ecological restoration covers diverse economic instruments, including carbon offsets, wetland banking, and biodiversity trading schemes. Despite some countries have experimented with these mechanisms for decades, the notion that ecological restoration outcomes can be traded in markets remains controversial. Advocates of the approach expect market-based instruments to add flexibility, effectiveness and financial resources to traditional restoration policies; critics, on the other hand, fear that it will erode intrinsic motivations to protect nature, promote unequal access to ecosystem services, and promote undesirable commodification of nature. In this talk, I review the nature, challenges and controversies around the commodification of ecological restoration. I contend that, besides the widely recognized opportunities that the market approach may bring in the short term, the ecological restoration community needs to make due consideration of the less understood longer term impacts that commodification can bring in the values and institutions governing our relation to nature.

**K-07**

**Progress, challenges and perspectives of peatland restoration for climate change mitigation**
Hans Joosten
University in Germany, Germany

The Paris Agreement has made the world simple. We have one common goal: to limit global temperature rise to clearly below 2o. The physical consequence is, that we have to reduce global net greenhouse gas emissions by 2050 to 0 (zero). This '0 for all' implies that sectors cannot hide any longer behind others ("I am too important to reduce, so others have to do more") and that after 2050 transferring emission reductions from one sector/company to the other ("offsetting") becomes impossible. A further consequence is that the curve to decreasing emissions has to be reached as soon as possible: delaying the peak with a decade will necessitate a so fast decrease that insufficient time is left to transform the economy. As, furthermore, these goals have to be reached "…in the context of sustainable development and efforts to eradicate poverty", the challenges are enormous. On the other hand, we still have 30 years to reach the 0-emissions goal, so that reduction 'only' has to be 3% per year.
The challenges with respect to peatlands are that until 2050 the use of the fossil resource 'peat' and of drained peatlands has to be completely stopped. This will require the large-scale rewetting and restoration of current and former peat extraction sites. For peat as a raw material for high-quality growing media this means that climate-friendly alternatives have to be found, e.g. by Sphagnum farming.
The fading out of the use of drained peatlands for agriculture and forestry is, however, the largest restoration challenge, as worldwide until 2050 almost 20,000 $km^2$ of drained peatland have to be rewetted annually to comply with the Paris Agreement. As the growing demand for biomass implies that these peatlands must largely maintain their production function, peatland agriculture and forestry must rapidly advance the development of wet cultivation techniques, i.e. of paludicultures, which – per definition – minimize greenhouse gas emissions and stop subsidence.

**O-1 - Restoration for Biodiversity**

**O-1.1**

**The snowballing of a 'new' long-term ecological restoration experiment; a 13-year establishment story from Australia.**
Adrian Manning
The Australian National University, CANBERRA, Australia

Establishing 'new' long-term ecological restoration experiments isn't easy in the age of short-termism. Yet, we need long-term experiments more than ever. Here I describe the 13 year genesis of a 'new' long-term ecological experiment that has snowballed far beyond original expectations. The 'Mulligans Flat – Goorooyarroo Woodland Experiment' on the outskirts of Australia's capital city, Canberra, is a research partnership between government, universities and an NGO.
The aim of the project is to find ways of improving critically-endangered 'box-gum grassy woodlands' for biodiversity through manipulating ecological processes. Original treatments include the addition of 2000 tonnes of coarse woody debris, prescribed burning, and exclusion of kangaroos. Response variables include: plants, fungi, birds, small mammals, reptiles and invertebrates. Addition of a feral predator-proof fence in 2009 allowed expansion of research to include the strategic multi species reintroductions of locally-extinct species, including ecosystem engineers. The experiment provides a strong inferential framework for tracking the effects of restoration treatments on woodland biodiversity over coming years. This is informing adaptive management of similar woodlands in the region. It also provides a research framework for a range of collaborators working towards a 'whole-ecosystem' understanding of these grassy woodlands.

The broader aim is for the experiment to become an 'outdoor laboratory' for ecological restoration research, and community and student learning. We are now well on the way to acheiving this. An innovative Government-University-NGO partnership has emerged to co-manage the site, and a comprehensive community engagement program has been developed. Now in the detailed planning stage, the centerpiece of the project is a new 'Woodland Learning Centre' that will become the hub that integrates research, restoration and community engagement and learning. I will reflect on the 13 year journey, and highlight some factors that I believe have led to the successful establishment and growth of this long-term project.

**O-1.2**

**Bird diversity as an indicator of ecosystem recovery in an urban Mediterranean woodland**
Eman Calleja, Timothy Micallef
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The diversity of avifauna is a strong indicator of ecosystem health, the availability of food and suitable habitat. Habitat preference in particular, would influence which species frequent a site, either in passing, or as residents. Nevertheless, the availability of such suitable natural habitat in urban settings is difficult to come across in many cities, as such areas are often lost to development. In this paper we focus on a small valley wedged between a densely populated urban area, that has been the focus of a woodland ecosystem restoration project in the 1990s and 2000s. The developing woodland is studied in terms of the bird populations that it sustains which are hereby used as an indicator of ecosystem recovery. Thus, we collected data on the species that frequent and inhabited the study site by capturing the birds, as part of a National bird ringing program managed by Birdlife Malta between 2013 and 2018. Data collected during 106 sessions included species, age, sex, weight, wingspan size, muscle score, fat score and habitat preference. In all, 542 birds belonging to 74 different species were captured, ringed and released, 87 of which were recaptured within the same 5-year period. Only 18.6% of the birds were migratory, whereas 45% were wintering, and 36.3% were residents. The quantity and species of birds captured was strongly influenced by the habitat type, month, age and time of the day. In some species, younger birds were more frequently captured earlier in the season. Our study indicates how the ecological restoration of pockets of land within urban settings can provide valuable ecosystem services, part of which include providing refuge for bird species that reside in these sites year-round or use them to overwinter.

**O-1.3**

**Vegetation responses three decades post-restoration in a Nevada, U.S., sagebrush steppe community invaded by pinyon-juniper**
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Expansion of native pinyon-juniper woodlands can decrease shrub and herbaceous cover in the Intermountain West, U.S., affecting habitat quality and biodiversity. Removing pinyon-juniper (*Pinus monophylla-Juniperus osteosperma*) woodlands in former sagebrush ecosystems has a long management history, and short- and long-term monitoring can produce different descriptions of understory plant community responses. We revisited a 500 mm average precipitation site in the sagebrush steppe of western Nevada, U.S., 32 years after tree thinning and seeding treatments had occurred. We measured plant canopy cover and ground cover, perennial canopy gaps, shrub and tree density, and species richness within historic treatment plots arranged in a 3-block randomized design. Blocks were treated with three levels of clearing, and treated plots were seeded with a mix of non-native and native perennial grasses, forbs and shrubs. We found significantly lower foliar cover of *P. monophylla* in treated plots (average of 2-8%), relative to controls (32%). However, *P. monophylla* seedlings (< 0.5 m tall) were detected throughout all plots, indicating potential for return to tree dominance. We found that foliar cover of perennial graminoids and shrubs was higher in all treatments (600-860% higher and 440-540% higher, respectively). Invasive annual species were highly variable, but foliar cover was generally higher in treated plots (average of 21-27% vs. 8% in controls). Finally, control plots contained significantly larger perennial canopy gaps compared to all treatments (average of 318 cm vs. 104-133 cm), and significantly more woody litter cover than clear cut plots (average of 14% vs. 3%). These results suggest tree thinning and removal can increase shrub and perennial grass cover, especially in conjunction with seeding, but tree recolonization over the long-term is possible. Some vegetation components, notably perennial forbs, did not respond well to treatments, and alternative strategies may be needed to achieve the goal of increased wildlife habitat value.

**O-1.4**

**Effects of perennial wildflower strips on plant and bird diversity in intensively-farmed agricultural landscapes**
Annika Schmidt, Heiner Hensen, Thomas Stahl, Sabine Tischew
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In Europe, most countries subsidise the establishment of perennial flower strips on arable land within agri-environmental schemes. Although they are used for foraging and reproduction by a variety of organisms, the populations of many farmland birds continue declining. Whilst many studies focus on flower strips established with cultivars or of non-native species, there is little known about the effects of perennial species-rich wildflower strips on farmland birds.
In the federal state of Saxony-Anhalt (Germany), 40 perennial wildflower strips, sown in 2015 and 2016 with a species-rich mixture from regional seed propagation, were evaluated with regard to vegetation composition and structure as well as effects on bird communities. We chose either single or several aggregated wildflower strips, both types in full sun or shaded (i.e. close to woodlands) and two control variants (arable land in full sun or shaded); each type with 10 repetitions. Vegetation surveys were made on stratified-randomised located plots. Breeding birds were monitored by using territory mapping.
Compared to arable land, all wildflower strips showed a species- and flower-rich vegetation. Breeding bird and territory abundance as well as number of bird species was larger on arable land with flower strips, too, particularly in full sun conditions. Skylark, corn bunting, common whitethroat and red-backed shrike showed significant higher number of territories and breeding-continuity on arable land with flower strips.
Wildflower-rich seed mixtures can be established successfully under a variety of conditions, supporting characteristic species in agricultural landscapes. Perennial wildflower strips that comprise about 6-10 % of a field can significantly enhance local populations of farmland bird species, especially in full sun conditions. Thus, our study revealed important result for the optimization of agri-environmental schemes not only in Germany but in whole Europe.

**O-1.5**

**Invertebrates in restoration ecology: a review**
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Invertebrates are of major importance in ecosystems as they provide many ecosystems services and perform key functional roles. Their life history traits involve rapid responses to environment changes and disturbances. Here, we aimed at assessing how invertebrates can be considered in ecological restoration. A literature review allowed us to categorize the role of invertebrates according to five topics: i) effects of ecological restoration on invertebrates; ii) invertebrates as bioindicators of restoration success; iii) ecological restoration for invertebrates; iv) ecological restoration by means of invertebrates and finally v) ecological restoration because of degradations due to invertebrates. These topics are here illustrated by concrete examples based on papers and empirical researches. The review highlights the knowledge and consideration levels of invertebrates in ecological restoration. It also provides more information about the usefulness of invertebrates for ecological restoration purposes and outlooks.

**S-1- The socio-economic-political context of ecological restoration in a time of climate change**

**S-1.1**

**An overarching, integrated framework for setting ecological restoration in its socio-economic-political context**
Berit Kohler
NINA, TRONDHEIM, Norway

Extensive ecological restoration practice has highlighted the existence of social, economic and political aspects that can be decisive for project efficiency and success. All restoration activity takes place in a larger socio-economic-political context, constituting for example drivers and barriers for its realization. A rather substantial body of research literature and presentations at former SER conferences have shed light on single social-economic or political aspects. The attempt will here be made to build an overarching (visual) framework scheme that sets ecological restoration in its societal context and integrates all existing restoration-related social, economic and political aspects. Such a framework scheme will potentially be highly beneficial for initiating, planning, implementing and evaluating future ecological restoration projects, specifically in a time of climate change when targets might be shifting.

The first part of this presentation will introduce and set the frame for the core of this session, i.e. the following presentations that will shed light on different dimensions related to this topic. In this first part will also a first, basic sketch of such an overarching, integrated framework scheme be presented.

A second part will after the core presentations, at the end of the session, provide the presenters together with the audience the possibility to discuss, adjust, refine and complete that framework scheme.

**S-1.2**

**Ecosystem restoration seen through the lens of a social-ecological system analysis**

Ãžórunn Pétursdóttir
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The social-ecological system framework (SESF) designed by Elinor Ostrom and colleagues is a valuable tool for unpacking and identifying the multiple components of any specific natural resource management social-ecological system (SES). A full SESF analysis provides a comprehensive overview of a SES´s social and ecological structures and functions. In cases where the exploitation of natural resources is estimated to be unsustainable, the SESF analysis is also useful for identifying potential underlying causes for any exploitation driven resource depletion through the focal action situation of the SESF. It can also give ideas on how a broken ecosystem resilience might be re-established.
The goals and targets for re-establishing and increasing the ecological resilience of degraded ecosystems need to be well defined and clear. Furthermore, they should take into account that the restoration activities will most likely be implemented parallel to continued resource exploitation; thus the restoration process might be more complex than else.
To achieve a long-term restoration progress, the need for ecosystem restoration and the selection of applicable approaches must be approved by the majority of the actors and agents involved in the focal action situation of the respective SES. Furthermore, the ecosystem restoration process has its own SES that is embedded in the SES of the natural resource management system. Thus, to re-establish ecosystem ecological resilience it´s essential to unpack the SES of the restoration and make all the diverse social-ecological processes, elements and variables driving that system visible and clear to the individuals involved.
In this presentation I will discuss the main various socio-economic and ecological aspects that need to be addressed in an ecosystem restoration process that is a part of a natural resource management system and provide an overview of the various governing and management steps that need to be included in an effective ecosystem restoration.

**S-1.3**

**The risk of ignoring biodiversity when restoring for ecosystem services**

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With increasing anthropogenic pressure on nature, ecological restoration has gained leverage in the science and policy agendas. Traditionally, the focus of restoration was on biodiversity, but the emphasis has shifted towards restoring ecosystem services such as climate change mitigation either through reforestation for carbon sequestration or restoring wetlands to reduce carbon emission. Restoration is seen as contributing to win-win solutions, ensuring the delivery of ecosystem services, while also conserving biodiversity. While the synergies in restoration may be attractive for the policy community there is growing concerns that conflicts between biodiversity and ecosystem services might become more prominent. We address these concerns by examining how restoration can be practiced in ways that promotes synergies and minimize trade-offs. We provide a literature review on trade-offs, with a focus on climate mitigation, and derive novel insights from three case studies from Nordic countries. Despite beneficial relationships between biodiversity and ecosystem services have been identified in the literature, evidence from our case studies suggest that biodiversity may require compromises with ecosystem services and that the relationship is variable. The cases show that while the relationships were principally of a win-win nature, outcomes are dependent on both time scale and restoration context including goals, ecosystem conditions and policy. We also point to shortcomings in the policy process, with post-facto catch-up in terms of planning, deficiency to subject restoration to policy evaluation, making it difficult to judge outcomes, and a need to acknowledge the risks of trade-offs at an early stage in the policy cycle.

**S-1.4**

**Integrated success evaluation of restoration - joining ecological with social, economic and political objectives**

Berit Kohler, Dagmar Hagen, Marianne Evju, Magni Olsen Kyrkjeeide
NINA, TRONDHEIM, Norway

Future restoration activities can be improved if their success is properly evaluated. Assessing the outcome of river restoration projects facilitates adaptive management and can increase the efficiency of future restoration projects. A large variety of indicators has been developed and used to evaluate success regarding ecological and structural objectives of restoration. There is, however, a lack of clearly measurable socio-economic and political indicators. Such indicators are needed to ensure sustainable restoration management and to develop success evaluation schemes that integrate all of these dimensions. We use the following data sources to analyze indicators and modes of integration : 1) data from a national survey of all restoration activities (in all habitats) in Norway since the year

2000; 2) data from a paper review of projects describing evaluation of restoration success in Europe/North America since the year 2010; and 3) existing examples for integrated success evaluation of ecological, socio-economic aspects.
Based on the findings and the existing body of literature on the topic will we develop recommendations on an encompassing spectre of socio-economic and political indicators and their potential integration in future success evaluation schemes.

**S-1.5**

**The science needed for the Bonn Challenge - a question of framing and perspectives**
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*The Bonn Challenge* is a policy-driven platform that has catapulted the field of ecological restoration onto the global science-policy stage. Restoration is put forward an ideal climate mitigation tool, whereby biodiversity is restored to degraded landscapes, carbon is stored and livelihoods secured through increasing natural capital. This presents an unprecedented opportunity for ecological restoration, in scaling up its impacts and remit to the global level. This situation also presents an array of challenges and potential pitfalls that it will be important to address swiftly as the Bonn Challenge, with its ambitious aims, unfolds.
The policy side of the equation has forged ahead and placed ecological restoration as a major player in the science-policy interface, such that now we need to do a SWOT analysis of the strengths, weaknesses, opportunities and threats of such science-platforms. We have some serious catching up to do, both in terms of science backing up the programme and in terms of communication between different stakeholder groups. The overall framing needs to ensure that the restoration actions are the most appropriate and do, in fact, meet the objectives set. In particular, the overall global approach needs to be more explicitly inclusive of restoration of a wide range of ecological habitats that offer carbon sequestration options as well as high biodiversity, since the framing so far has been heavily skewed (including in its language) towards forests. In essence we are weakening the potential to reach the Aichi Target 15 or the Bonn Challenge goals by having a bias towards particular biomes or habitats, especially since a standardised comparison of biomes in terms of carbon storage belowground has not yet been made. This talk will outline some of the key science and communication/framing discussions needed to create the best possible evidence and knowledge co-creation base for the Bonn Challenge.

**W-1 How can restoration practitioners be supported to make 'evidence-based' decisions?**

Chairs: David Thomas and Nancy Ockendon

Workshop summary:
Use of evidence helps ensure that restoration interventions are both effective and efficient; this workshop will examine the evidence needs of practitioners (types of information and how it is presented and accessed) alongside the channels through which researchers currently deliver their findings, to gain insight that will help improve impact.

**O-2 - River restoration**

**O-2.1**

**Alternate ecological and functional trajectories for riparian forests along channelized versus natural reference rivers**
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Worldwide, riparian forests have been impacted by river regulation and channelization. Recently, efforts to restore degraded riparian habitats have expanded in scope and cost. However, given the profound alteration of natural disturbance regimes and modifications to abiotic conditions induced by human infrastructure, the efficacy of restoration actions is questionable. In many cases, ecological communities may already be so modified as to approach transient or new states, making the return to the desired state difficult or impossible. To evaluate the potential effects of restoration efforts, it is thus of great concern to compare current trajectories of degraded rivers to historical trajectories of reference rivers. Using forest inventories within a chronosequence modelling approach, we assessed whether ecological and functional trajectories varied with age between the channelized and regulated Rhône River (n = 65 plots) and the relatively unmodified Drôme River (n = 69 plots). Results showed that the shift in functional traits (SLA, wood density) with floodplain age is accelerated along the Rhône River and that patterns of trait divergence (wood density, seed mass) were more pronounced along the Drôme River. Stand attributes of basal

area and mean diameter of live and dead trees increased with age along the Drôme River but decreased along the Rhône River, while basal area of exotic tree species increased only with age along the Rhône River. Furthermore, forest composition and structure strongly diverged between the two rivers. This was mostly due to the greater abundance of exotic species and of large diameter trees along the Rhône River. Overall, we found profound differences in ecological succession patterns between the two rivers, highlighting rapid and likely irreversible divergences in trajectories. Along the highly modified margins of the Rhône River, riparian forests could be regarded as a “novel ecosystem” for which restoration is likely to be difficult.

**O-2.2**

**A demonstration site network to assess river restoration efficiency in different contexts/environmental conditions**

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Many hydromorphological river restoration works have been achieved over the last 15 years under the impulse of the Water Framework Directive (WFD). However, an important lack in the monitoring and assessment of the efficiency of those works still remains and is often reported. In 2010, The French Biodiversity Agency (FBA), French water agencies and National Research Institute of Science and Technology for Environment and Agriculture (Irstea) developed a specific methodology to monitor river restoration projects, named “Minimal Scientific Monitoring” (MSM). The MSM focuses on the multi-annual evolution of three components of the river environment, namely hydromorphology, physico-chemical parameters and biota. On each site studied, a *before-after-control-impact* design is implemented, meaning monitoring is led before and after restoration, and upon restored sites and control sites. In addition, all field protocols implemented are standardized (WFD standards if available) to ensure homogeneous data collection on all stations.

One of the most important challenges when analyzing the effects of river restoration is to consider the relevant explanatory variables. Often, scientific publications do not include restoration work details (sizing and heterogeneity of recreated watercourse for example), nor do they include environmental variables.
MSM is an attempt to fulfill this gap, by including physico-chemical, hydrology and water temperature monitoring in addition to the biological and hydromorphological survey.
Following these parameters across a long-term monitoring and upon control and restored sites will help (i) considering the great diversity of river types and pressures existing upon the watershed and (ii) understanding the river system and biological communities evolution due to local and large-scale modifications.
All restoration projects on which the MSM is implemented constitute the “demonstration sites network”. This approach aims thus to generate standardized data on the long term and, more generally, to increase knowledge about the efficiency of the river restoration works at the national scale.

**O-2.3**

**Local and landscape-scale control of restoration success in headwater streams**

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Effects of anthropogenic stressors on community structure and ecosystem functioning can be strongly influenced by local habitat structure and dispersal from source communities. Catchment land use increases the input of fine sediments into streams, clogging the interstitial spaces of benthic habitats. Aquatic macrophytes enhance habitat heterogeneity and mediate important ecosystem functions, being thus a key component of habitat structure in many streams. Therefore, the recovery of macrophytes following in-stream habitat modification may be prerequisite for successful stream restoration. Restoration success is also affected by dispersal of organisms from the source community, with potentially strongest responses in relatively isolated headwater sites that receive limited amount of dispersing individuals. We used a factorial design in stream mesocosms to study the independent and combined effects of an anthropogenic stressor (sand sedimentation), local habitat (macrophytes, i.e. moss transplants) and enhanced dispersal on organic matter retention, algal accrual rate, leaf decomposition and macroinvertebrate community structure. All ecological responses were simple additive effects with no interactions between treatments. Sand reduced algal accumulation, total invertebrate density and density of a few individual taxa. Mosses reduced algal accrual rate and algae-grazing invertebrates, but enhanced organic matter retention and detritus- and filter-feeding invertebrates. Mosses also reduced macroinvertebrate diversity by increasing the dominance by a few taxa. Mosses reduced leaf-mass loss, likely because the organic matter retained by mosses provided an additional food source for leaf-shredding invertebrates and thus reduced shredder aggregation into leaf packs. The effect of mosses on macroinvertebrate communities and ecosystem functioning was distinct irrespective of the level of dispersal, suggesting strong local control of community structure even under enhanced dispersal. Therefore, re-establishing key habitat features, such as natural stream vegetation, may be a prerequisite for ecosystem recovery in boreal streams.

**O-2.4**

**Large wood as a driver of fish abundance in Swedish streams: Who benefits and where?**
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Rivers are heavily affected by anthropogenic impacts that threaten many fish species. Among restoration measures, the addition of large wood (LW) in streams has been showed to increase fish abundance. However, what species benefit from LW, to what extent relative to other drivers, and what factors influence LW quantity is not clear, which limits our ability to use LW as an effective restoration measure.
Here, time series data (from 1993 to 2016) including 3641 streams across the whole Sweden were used to investigate 1) beneficial effects of LW on the abundance of brown trout *Salmo trutta*, Atlantic salmon *salar*, and sculpins *Cottus gobio* and *C. poecilopus*, while accounting for other abiotic and biotic factors, and 2) the drivers of LW abundance at country-wide scale.
LW benefitted trout, but not salmon or sculpin abundances, and the effects were larger when shaded water surface was low. Trout abundance was most strongly (negatively) correlated with stream width and depth, increased with annual average air temperature, and decreased with predator abundances, i.e. burbot (*Lota lota*) and Northern pike (*Esox lucius*). Salmon abundance responded most strongly to stream width and altitude (positively and negatively, respectively), while sculpin abundance were mostly negatively correlated to air temperature and altitude.
The quantity of LW strongly decreased with stream width, and, to a lesser extent, with stream depth, altitude, air temperature and forest age, while it increased with stream velocity, slope and forest cover.
Our results suggest that LW can be used as an effective restoration tool for brown trout in shallow and narrow streams, especially in unshaded areas. Hence, the addition and maintenance of large wood could buffer the negative effects on trout of forest clearance along streams.

**O-2.5**

**Supporting management decision-making in the dam-free Sélune River project (France): taxonomic and functional successional patterns**
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The removal of the two hydroelectric Sélune River dams (Normandy, West of France) –36m and 16m high, is expected by 2019 and 2021 respectively. It is a unique European renaturation project freeing an entire coastal river. This study, part of a global scientific program, focuses on 19kms of river stretch (the first disappearing lake's length). Since 2015, the usual 1m summer tidal range of the Vezins impoundment is not established anymore in order to make sediment management easier during the emptying. Between early 2017 and late summer 2018, the water table has been slowly reduced to conduct these 560 000 $m^3$ sediment flow prevention engineering works. The floodplain progressively goes back to its normal course. Hectares of dewatered muds were rapidly colonized by spontaneous vegetation over the following months. The former lake is slowly being replaced by a river meandering through resurgent fields and wetlands. The 4-year emptying has made a close vegetation change monitoring possible, highlighting how to ecologically restore the valley. This 2015 to 2018 survey is based on spatial (lateral and longitudinal variations) and temporal (intra- and inter-annual shifts) observations of riparian vegetation communities. The aim is to predict the vegetation's ability to passively and ecologically restore the riparian area of the new Sélune River. It focuses on three axis: i) the temporal dynamics of the colonizing species, ii) the influence of environmental variables in spatially structuring communities, and iii) the functional successional patterns of the process. Species traits related to colonization and sediment stabilization potentials within the habitat mosaic are treated. We discuss how management decisions related to the ecological restoration of the valley could be supported by the community ecology and trait data obtained. Finally, we suggest prioritizing passive restoration issues according to the functions assigned in this new valley.

**O-2.6**

**Evaluation of a river restoration project rehabilitating historical meanders: a case study for the Dommel**
Sophie Vermeersch, David Buysse, Johan Coeck
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The channelisation of water courses is a threat for the diversity and abundance of ecological communities. Changes in the physical habitat compromise the survival of numerous species. The aim of this restoration project was to rehabilitate historical meanders to create a sound initial situation, on which a further spontaneous development of the river system should be possible.
We evaluated whether the achieved river restoration measures have created a larger structure diversity and if the

habitat suitability for diverse biotic groups has been increased.
The habitat suitability and the biotic groups in the different stretches were quantified and compared in terms of habitat measurements and population sizes (fish, benthic invertebrates, macrophytes) in a 'restored meandering river reach' and a 'non-restored reference reach'.
The river is characterized by relative mineral-poor water. These types of water courses are low to moderately productive. Aquatic plants should be well-developed and often dominated by pondweed vegetation. Nevertheless, the vegetation is mainly dominated by species characterised by a nutrient-rich environment. Overall, the presence of macrophytes enhances the abundance and diversity of the juvenile fish. The abundance of fish species was larger in restored reaches compared to reference reaches. A better community structure in the restored reaches, indicates that more species are reproducing in these areas. This is particularly well demonstrated by large numbers of juveniles from different age classes. One can thus conclude that restored reaches not only attract adult fish from the surrounding habitats, but also exhibit the capacity to enlarge self-sustaining fish populations by reproduction and are able to shelter sensitive reference species of benthic invertebrates, which are a benchmark required by the European Union Water Framework Directive.
Furthermore, we demonstrate the influence of an incidental factor such as water pollution on the evaluation of the river restoration project.

## S-2-Grassland restoration in Europe: Current status and furture prospects

### S-2.1

**How have we studied seed rain in grasslands and what do we need to improve?**
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Seed rain, the number of seeds reaching an area, is a process that plays a key role in recruitment and regeneration in plant communities. A better understanding of seed rain dynamics is therefore a critical step for restoration practices. A wide variety of methods to study seed rain in grasslands are available, but there is little agreement to which is the most appropriate one. In a recent review published in the journal Restoration Ecology, we: (1) assessed where, how, and why research on seed rain has been carried out; (2) examined how methodological design and results have been reported; and (3) provided guidelines for future research on seed rain in grasslands. We found a remarkable unbalance of the numbers of studies between grassland types, which becomes even more dissimilar across global climatic ranges when the area covered by each grassland type is addressed. We also found a great disparity of methods and data being reported across studies. Despite recent progress in understanding seed rain dynamics, large knowledge gaps in important issues such as the role of native dispersers, method efficiency, and application of mechanistic models still persist. We propose guidelines for the implementation of minimum standardized methodology and data reporting, which will foster higher quality, transparency, reproducibility, and value of seed rain studies and grassland restoration. Recent practical experiences with a seed rain study in a tropical grassland exemplify some challenges and the relevance of the application of the guidelines proposed in this review.

### S-2.2

**Grassland restoration in Estonia: aims, methods and implications for biodiversity**
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In the beginning of 20$^{th}$ century, 1/3 of mainland area of Estonia – 18 000 km$^2$ – was covered by semi-natural grasslands. Since then, similarly to all other regions in Europe, changes in land-use resulted in abandonment and conversion of grasslands and disappearance of cultural landscapes. In 2013, only 270 km$^2$ (1.5% of historical coverage) of semi-natural grassland areas were under suitable management (grazing or mowing), necessary for their long-term persistence.
We will provide overview of the aims, methods, sucesses and failures from the largest grassland restoration project in Estonia – "Life to Alvars" (LIFE13NAT/EE/000082). During 2014 to 2020, project aims to double the area of managed dry calcareous alvar grasslands in Estonia by restoring 2500 hectares of overgown areas and creating conditions for local people and farmers to re-establish grazing. Circa 600 land-owners and 41 local farmers and farming companies are participating in the project. Since the beginning of project, we have gained considerable new knowledge about large-scale grassland restoration, starting from the awareness raising and public engagement to the best techniques for actual restoration. Extensive biodiversity monitoring has provided thorough knowledge about the pre-restoration conditions, and allows to draw conclusions about the effects of restoration on biodiversity.
By 2018, restoration activities that have been completed in more than 2000 hectares have vastly changed local landscapes and raised awareness about the value of grasslands. Moreover, restoration activities have changed

economic conditions and lifestyle choices among local people. Implementation of infrastructure necessary for grazing (fences, animal drinking places, shelters, gates), coupled with the support system for managing semi-natural areas have created incentive for local farmers to increase their livestock and move animals from cultural grasslands to restored alvars. Plant biodiversity has shown unexpectedly rapid recovery, likely due to landscape-scale approach to restoration and well-preserved soil seed bank.

**S-2.3**

**Restoration of open sandy grasslands**
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Natural open interior sands represent a highly threatened habitat in Europe. However, these originally nutrient poor biotopes were affected by pasture cessation, rapid successional overgrowing accelerated by increased aerial N-deposition and the spreading of competitive eurytopic plants. The effective restoration approach to degraded or destroyed open sand vegetation sands are thus crucial for the survival of the associated biota. We investigated restoration of degraded psammophytic vegetation in the southestern part of the Czech Republic. Competitive strong grass *Calamagrostis epigejos* has formed compact cover on many hectares in large area formerly dominated by valuable psammophytic grasslands, therefore the upper nutrient rich layer was scraped up to 50 cm below the surface to expose nutrient poor sands. Altogether 15 permanent plots (each 5 x 5 m) were established between 2012 and 2014, each year five new plots on sites with scraped organic layer, in which relevés were recorded annually. Phytosociological relevés were made also in references sites with target psammophytic vegetation and in degraded plots prior the restoration measure. The target psammophilous species colonized the open sands immediately from close well-preserved vegetation fragments. Out of 97 higher plant species recorded in total, 23 were classified as threatened. The number of target plants increased three times while undesirable synanthropic species decreased by half after five years compared to controls. Following species were recognized as the most successful colonizers of restored sites: *Corynephorus canescens*, *Rumex acetosella, Trifolium arvense, Filago minima, Agrostis vinealis, Verbascum lychnitis* and *Artemisia campestris*. The results of multivariate analyses revealed that spontaneous development of restored plots run fast towards psammophytic vegetation in reference sites. The optimal restoration of highly eutrophicated open sandy grasslands is combination of larger scaled topsoil removal with other smaller scaled restoration measures, e.g. cutting trees or using various additional disturbances.

**S-2.4**

**Beneficial effects of restoration practices can be thwarted by climate extremes**
Simona Maccherini[1], Giovanni Bacaro[2], Michela Marignani[2]
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The impacts of climate extremes on species, communities and ecosystems have become critical concerns to science and society. Under a changing climate, how restoration outcomes are affected by extreme climate variables is a largely unknown topic. We analyzed the effects of experimental factors (grazing and sowing of native species), extreme climate events (intense precipitation and extreme temperatures indexes) and their combination on the restoration of a dry, calcareous grassland in Tuscany (Italy) with a 1 year before/15 years after, control/impact (BACI) experiment. Grazing had a beneficial effect on the diversity of the grassland, while sowing had a negligible impact. The climatic index that most affected the entire plant community composition was the number of very heavy precipitation days. The interaction of grazing and extreme climatic indexes had a significant detrimental effect on restoration outcomes, increasing the cover of generalist species and decreasing the cover of more valuable species such endemic species. In the richer grazed plots, species richness showed a lower sensitivity to the average precipitation per wet day. In grazed site restoration outcomes can be negatively influenced by the intensification of precipitation and temperature extremes. In a context of progressive tropicalization of the Mediterranean area, to assist managers setting achievable restoration goals, restoration practitioners should consider that climate extremes might interfere with the beneficial effects of restoration practices.

**S-2.5**

**Meeting Aichi Target 15: Efforts and further needs of ecological restoration in Hungary**
Katalin Török, János Bölöni, Ferenc Horváth, Anna Kövendi-Jakó, Melinda Halassy, Katalin Szitár
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The Aichi Biodiversity Targets of the Convention on Biological Diversity define 15% of degraded land to be restored by 2020. To measure the progress, the Green Infrastructure and Restoration Prioritization Working Group developed a land cover classification concept based on ecosystem condition from excellent (L1) to poor (L4). Based on the evaluation of the aggregated data of CORINE Land Cover, National Forestry Database and Landscape Ecological Vegetation Database (MÉTA), 7% of Hungary's territory can be assigned to L1, 10 % to L2 and 20 % to L3 and 64% to L4. The meta-database of restoration activities in Hungary was missing so far. We collected available information

on 653 restoration interventions implemented by nature conservancy and research organisations between 2002 and 2016. Considering our restoration inventory (that underestimates activities), only 1.25% of the restorable area (Level 2-4) was treated until 2016. Furthermore, we compared the restoration activities to the threat level of nine major habitat groups on the basis of the MÉTA database. The habitat groups most threatened by invasion were riverine and swamp forests (64.6% of their area) followed by dry grasslands (37.2%). In contrast, invasion in dry grasslands were controlled in most cases (on 16.6% of the threatened area), while riverine and swamp forests were controlled on only 2.9% of their threatened area. Saline grasslands and wet meadows were threatened by adverse water management on over 80 000 hectares, and wetland restoration was implemented on 27.5% of their threatened area. Adverse management threatened 146 704 ha grassland and 360 205 ha forests according to the MÉTA survey, and restoration efforts reached 8.8 and 6% of their threatened area, respectively. A major drawback of the data is the lack of knowledge on the outcome of restoration as no systematic monitoring was carried out or the results were not published.

## S-3 - How to use knowledge on land restoration to reach the UN Sustainable Development Goals?

### S-3.1

**The role of land restoration in the UN 2030 agenda**

Berglind Orradottir, Hafdis Hanna Aegisdottir
UNU-LRT, REYKJAVIK, Iceland

Our use and mismanagement of Earth's natural resources risk the health and productivity of Earth's ecosystems, threatening our livelihood and wellbeing. Our overexploitation affects not only the environment, but also our economy and social structure. This is recognized in the UN 2030 agenda which sets out 17 Sustainable Development Goals (SDGs) that aim to shift the world onto a more sustainable path.
To reach many of the goals we need to move from human centred land management which disregards harmful effects on nature, to nature based management where decisions are made based on the potential of the land. Land restoration is an important part of this approach as it can bring back biodiversity and ecosystem services, jobs, sustainable economy and healthier environment. To support this change capacity building in land restoration and sustainable land management is needed. The UN University Land Restoration Training Programme (UNU-LRT) focuses on such capacity building by offering annually six-month training for working professionals from developing countries, and custom built short courses around local challenges.
But outside the community of restorationists and land managers there is often a lack of knowledge of ecosystem processes and the benefits they provide. We thus need to reach across sectors, to people who use land for food, feed, energy or other raw material production, to succeed in such management shift. We also need to gain understanding of the needs of the producers, corporations and consumers to jointly find innovative sustainable solutions. This creates a need for educational material that can bridge the gap between ecology and economy. UNU-LRT is currently involved in creating such material, in the form of study cases and massive open online courses (MOOCs). We believe such capacity building initiatives are important to make the shift from business as usual approach to nature based solutions.

### S-3.2

**Knowledge on land restoration and the process for attainment of the Sustainable Development Goals**

Emmanuel Lignule
Environmental Protection Agency, NANDOM, Ghana

Land restoration often leads to improvement in the provision of ecosystem services, and can generate insights on how to use land restoration knowledge to reach the Sustainable Development Goals (SDGs). This talk is based on my knowledge and personal experience of restoration of agricultural land and riparian forest in northern Ghana. Some local communities in the area are engaged in re-vegetating bare patches of land along dams and rivers, which are used for agricultural and related purposes. Due to rainfall variability and drought, some farmers also practice soil erosion control measures, and water conservation tillage on their farms. Moreover, members of local communities have been engaged in making and enforcing rules for managing bushfires for reducing the seasonal shortage of grass for livestock grazing, and maintaining soil fertility for crop production. This approach to bushfire management has led to an increase in crop yields in some communities, where farmers now have more food for household consumption, and more income. The main drivers of land restoration in the area are community engagement, financial and material incentives, and competent leadership. Additionally, clear purpose and expectations with land restoration, and adaptation of land restoration to the local context make land restoration desirable for communities. These experiences show that, land restoration can lead to the attainment of SDG targets for poverty reduction (goal #1), sustainable agriculture and reduction of hunger (goal #2), and sustainable management of water resources (goal #6). Also, land restoration can be used to reach SDG targets for mitigating and adapting to climate change (goal #13), halting and reversing land degradation (goal #15) and revitalizing partnership for sustainable development (goal #17). These linkages suggest that, knowledge on the process and biophysical aspects of land restoration can be used for managing the SDG implementation process in order to reach the targets.

**S-3.3**

**Drivers of rangeland degradation in Lesotho and potential benefits of land restoration**
Malipholo Hae
Ministry of Forestry, Range and Soil Conservation, MASERU, Lesotho

The aim of this talk is to review drivers of rangeland degradation in Lesotho and explore the potential benefits of removing the drivers and restoring the land. Rangelands cover over 60% of Lesotho and are a very important resource as they provide food and water, medicines, income, forage for livestock, raw material for crafts and they are a base for tourism. Lesotho's rangelands are however under severe strain, characterised by rapid loss of productivity. Ecological services are in jeopardy because rangelands are being degraded through overgrazing, fires and plant invasions. Other drivers of rangeland degradation communal land tenure system, fragmented legal instruments, lack of political will and encroachment by croplands and settlements. Climate change also plays role in exacerbating rangeland degradation.
The key to regaining rangeland ecological services lies on restoration. Rangeland restoration brings about the potential of the land, regaining tremendously productive ecosystems that provide breeding and nursery grounds and ideal habitats for a variety of plant and animal species, and livelihoods for the people of Lesotho. A healthy rangeland results in improved quality of animal products that do well on the market for alleviation of poverty and creation of valuable business for local people. Rangeland restoration refurbishes sites with potential for aesthetic scenery and wetland restoration which are vital for improved tourism and job creation. Land restoration will thus address social, economic and environmental aspects and help reach many of the UN Sustainable Development Goals.
For the fact that rangelands cover a large area in Lesotho, their restoration should be a major focus of the government as their restoration offers a holistic approach to the betterment of the lives of the people.

**S-3.4**

**Transformation in pasture use in Kyrgyzstan: The costs of pasture degradation**
Azamat Isakov[1], Rebecka Ridder[2], Ulan Kasymov[2], Zhyrgalbek Kozhomberdiev[2]
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Pastures are considered an important natural resource and provide a basic source of livelihoods in Kyrgyzstan. Natural grasslands cover wide areas and not only provide self-sufficiency for rural households but also play an important role in strengthening social relations. Yet the post-socialist transformation in pasture management has resulted in a strong reduction in pastoral mobility, overgrazing and resource degradation, thus creating a challenge for sustainable land management.
This talk presents the empirical findings from two case studies implemented in southern Kyrgyzstan and evaluates the costs and benefits of different land use strategies with regard to pasture degradation. The study comparatively assesses alternative pasture management strategies, reflecting on their impact on pasture and livestock productivity. The farm gate values of sheep are used as an example of pastures' direct use values. The authors explore a potential intervention to mitigate pasture degradation: pasture rotation, highlighting the benefits of pasture improvement.
Furthermore, the talk presents the results of a stakeholder analysis and discusses why Kyrgyz pasture users do not engage in sustainable land management. It is argued that awareness on the relationship between overgrazing and pasture/livestock productivity has not been translated into action by pasture users due to the lack of consensus between experts and herders regarding what interventions are needed and how they should be organized. Further work on this is thus needed to find economic and environmentally viable solutions.

**S-3.5**

**A global perspective on how SDG target 15.3 can help integrate and accelerate other SDGs**
Barron Joseph Orr
United Nations Convention to Combat Desertification (UNCCD), BONN, Germany

In 2030, the international community will be brought to account regarding the achievement of the Sustainable Development Goals (SDGs) contained in the 2030 Agenda for Sustainable Development. For this to be accomplished in just 12 years, there is an urgent need to identify those targets which can accelerate progress and integrate the activities planned for multiple goals. SDG Target 15.3 calls on countries to "combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world". This target is focused on the sustainable management and restoration of our landscapes – the main pillars for achieving Land Degradation Neutrality (LDN) – in order to deliver many co-benefits, from biodiversity conservation and combating climate change to ensuring economic growth and human wellbeing. In this respect, the United Nations General Assembly, in its resolution 71/229 notes that "the achievement of the Sustainable Development Goals and targets, including Goal 15 and target 15.3, would serve as an accelerator to ending poverty and hunger, tackling inequality, empowering women and stimulating economic growth". It also "reiterates that degraded land, if recovered, would, inter alia, contribute to restoring natural resources, thus

potentially improving food security and nutrition in the affected countries, and in the process could, inter alia, contribute to the absorption of carbon emissions". Land restoration initiatives, if designed with the intent of achieving multiple benefits simultaneously, can not only help ensure land degradation neutrality is maintained or exceeded, but also contribute to meeting the targets of a range of other SDGs.

## O-3 - Restoration & Climate change

### O-3.1

**The potential of global peatland rewetting for climate change mitigation**

Paavo Ojanen, Kari Minkkinen
University of Helsinki, HELSINKI, Finland

Vast areas of peatlands have been drained globally for agriculture and forestry causing loss of peat and consequently carbon dioxide and nitrous oxide emissions. Rewetting of these peatlands has been proposed to reduce greenhouse gas emissions for climate change mitigation.
During recent years, evidence has accumulated showing that the carbon dioxide and nitrous oxide emissions from these drained soils vary substantially depending on land-use, soil nutrient status and climate. Rewetting effectively reduces or even completely stops these emissions. On the other hand, rewetting induces methane emissions from soil, their magnitude depending largely on soil nutrient status. The effect of rewetting on climate is further complicated because of the largely different radiative efficacies and atmospheric lifetimes of carbon dioxide, nitrous oxide and methane. Thus, the effect of peatland rewetting on climate also depends strongly on the studied time interval.
We combined area estimates of drained peatlands for different land-uses and climate zones with estimates on greenhouse gas emissions and removals from drained and rewetted peatlands. We then calculated the effect of global peatland rewetting on the emission/removal time series of different gases. Further, radiative forcing scenarios were constructed for each land-use and climate zone. We answer the following questions: How big effect on climate a global rewetting of drained peatlands would have? How much the increased methane emissions offset the benefit of decreased carbon dioxide and nitrous oxide emissions? For which time intervals, land-uses and climate zones rewetting is an effective tool for climate change mitigation?

### O-3.2

**Nitrous oxide emissions of pristine, forestry-drained and rewetted boreal peatlands**

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Drained peatlands, especially nitrogen (N) rich sites, are potential sources of nitrous oxide ($N_2O$). As this emission is caused by N mineralization connected to loss of peat, prevention of peat loss by rewetting can also prevent $N_2O$ emissions.
$N_2O$ emissions from drained peatlands are rather well known, but results from rewetted peatlands are still scarce. Also, $N_2O$ emissions at pristine peatlands have not been studied much, as the first studies showed very low emissions and lead to a conclusion that emissions are negligible due to anoxic soil conditions. Thus, our knowledge on the effects of drainage and rewetting is poor.
We analysed $N_2O$ flux data from 30 pristine, 53 forestry-drained and 21 rewetted boreal peatland study sites in Finland and calculated annual $N_2O$ emissions for each site. These data have been measured by our research group during the last 15 years and are mostly previously unpublished.
We discuss the following questions: Are $N_2O$ emissions at pristine boreal peatlands always negligible? What is the effect of forestry-drainage and rewetting on emissions? Do emissions return to pristine level following rewetting? How does the large variation in groundwater table level and peat N content among peatlands affect $N_2O$ emissions and the effect of drainage and rewetting on the emissions?

### O-3.3

**Land restoration: A solution to population vulnerability to climate change in Fakara Niger**

Mohamadou Habibou Gabou
Ministry of Environment and Sustainable Development, NIAMEY, Niger

This study was conducted in Kodo, a village of the rural commune of Fakara in Niger to assess the contribution of restoration works in reduction of population vulnerability to climate change. The main objectives of the study are to evaluate socio-economic and environmental impacts of restoration works. To achieve these objectives, we carried out questionnaires survey and floristic inventory and biomass estimation for herbaceous species. With the questionnaires, 90 farmers representing 9.67% of the active population of the area were interviewed on local farmers involvement in restoration works, the income earn by participating in these activities, and the socio-

economic and ecological impacts of these works. On field, plots of 1 m² were placed on the restored and fenced site according to a transact, to collect herbaceous species for floristic inventory and biomass estimation.
Results of the study shew that restoration activities help to recover degraded farm and rangeland productivity. Hence, 54 herbaceous species belonging to 17 families were inventoried on the restored and fenced area, three years after restoration activities. A mean of 6.055 kg/ha of dry matter is obtained from this site at that same period. Results also indicated that the mean revenue earns per day by a farmer is 4,333 FCFA with the realization of half moon and 5,200 FCFA with the realization of contour bunds. About 69% of the revenue obtained from participation to restoration activities are used to buy food for their families.
Restoration works help to ensure food security and forage for livestock, therefore to ensure better living conditions to their families. Thus, restoration works should be scaled up in Sub Saharan Africa to reduce population vulnerability to climate change.
**Key words:**Climate change; Land restoration; Vulnerability.

**O-3.4**

**Impact of Climate and Land Use Changes on Soil Erosion in Rift Valley Basin, Ethiopia**
Alemayehu Muluneh
Hawassa University, HAWASSA, Ethiopia

This study investigated impact of climate change and Land use changes and management practices on soil erosion at Bilate Sub- Basin, Rift Valley Lakes Basin, Ethiopia. The MarkSimGCM daily weather generator used to generate projected rainfall and temperature data using the outputs from an ensemble mean of four GCMs under RCP 2.6 (low) and RCP 8.5 (high) emission scenarios from the IPCC fifth Assessment Report (AR5). The baseline used as the reference period was 1986-2005. In this study, the soil los*s* model, Revised Universal Soil Loss Equation (RUSLE) integrated with GIS was used to estimate soil loss. The land use change scenarios were derived from the extrapolation of trends in land use change of the recent past (2000-2017) in to the near future (2030s). The results indicated that the projected climate change scenarios showed a marked increase in rainfall during long rainy season (12%). The maximum and minimum temperature is projected to increase by 0.51°C and 0.80 °C, respectively, under high emission scenario. The land use changes detected between 2000 and 2017 showed an increase in forest cover and a decrease in barren land, which might be attributed to a continuous tree plantation and reclamation of degraded lands by area closure which is clearly observed in the region. Under the current land use, the use of soil conservation practices reduced soil erosion rates by 55%. This implies that the soil conservation practices have a potential to offset the soil erosion problem in the region. Under the impact of coupled climate and land use change scenarios, the soil loss increased by 23%. Thus, projected increase of heavy rainfall as a result of climate change and future land use change scenario will increase soil erosion in the region. However, climate change influenced the soil erosion more strongly than the land use change.

**O-3.5**

**The multiple benefits of ecological restoration on eroded land**
Johann Thorsson, Kristin Svavarsdottir, Agusta Helgadottir, Anne Bau
Soil Conservation Service of Iceland, HELLA, Iceland

Revegetation activities that can be classified as *ecological restoration* aim at recovering degraded, damaged or destroyed ecosystems by accelerating local ecosystem processes. Ecological restoration increases biodiversity and resilience of restored ecosystem, and carbon is sequestrated. Organized restoration activities began in Iceland early last century by the Soil Conservation Service of Iceland (SCSI) and have since the 1980s focused increasingly on ecological restoration. To date approx. 2000 $km^2$ or more than 2% of the island have been restored with various methods. The aims of the projects vary, but with the current need of mitigating climate change with carbon sequestration, the obvious synergies in the mitigation and restoring degraded or eroded land have become apparent and have even become a driver in restoration.
In 2007, a monitoring project started aiming at determining carbon sequestration and successional trajectories in SCSI revegetation areas initiated after 1990. Its second phase is starting this year. Over 600 plots are now actively monitored for changes in vegetation cover, species composition and changes in soil C and N. Here we focus on successional trajectories in those areas and relate them to carbon sequestration based on results from the first phase that ended in 2011. Revegetation activities enhanced species richness; however the increase varied depending on methods with the fewest species occurring in lupine plots but more species in fertilised plots with and without sown grasses. Rate and direction of vegetation succession and carbon sequestration were also greatly affected by revegetation methods. Our results suggest that functional ecosystems can be developed through revegetation but not all methods ensured favourable successional trajectories for ecological restoration. Hence we need to assure that climate change mitigation activities enhances multiple benefits of ecological restoration and take into account the three appropriate UN conventions Iceland has agreed to, i.e. CBD, UNFCCC and UNCCD.

**O-3.6**

**Deciphering carbon dynamics in volcanically influenced peatlands**

Susanne Claudia Möckel, Egill Erlendsson, Guðrún Gísladóttir
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Even though at similar latitudes, environmental conditions in Iceland differ from those in other sub-arctic regions, not least owing to the influence of volcanism. Standards commonly used to estimate carbon stocks and predict carbon dynamics are therefore not necessarily applicable to Icelandic peatlands. The andic characteristics of Icelandic peatlands may possibly alter carbon storage processes compared to peatlands at similar latitudes in non-volcanic areas. Icelandic peatlands contain more mineral material, less organic material, and less carbon, than their northern counterparts. It is often assumed that the comparatively low carbon content of Icelandic peatlands equates with comparatively low carbon emissions. On this basis, the value of capturing carbon in ecologically restored peatlands in Iceland has been questioned. In our view, the current state of knowledge about carbon dynamics, and their underlying processes in peatlands of subarctic volcanic environments does not allow for such assumptions to be made. Here, we present the first results of an ongoing project which seeks to decipher the carbon dynamics of volcanically influenced peatlands in Iceland, for example by disentangling some of the factors that control carbon stability in Icelandic peatlands, e.g. vegetation characteristics, content of allochthonous mineral material, carbon quality, and soil fertility. Peat samples, from three sites forming a transect from the coast to the highland fringe in Austur-Húnavatnssýsla, North Iceland, are being analysed. Vegetation characteristics differ between the sites; *Eriophorum angustifolium* dominates the coastal site, *Carex rostrata* the site at the highland fringe. Several co-dominant species, including *Carex nigra,* and various flowering plants and dwarf shrubs, characterize the lowland site. Measurements of carbon respiration of selected soil horizons via long-term incubation at 5°C, 15°C and 25°C suggest that the amount of stored carbon is not directly related to carbon emissions.

## S-4 - The challenges of large-scale landscape restoration-from theory to practice

### S-4.1

**The challenges of large-scale landscape restoration? an introduction**

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The last decade has seen a significant increase in the international prioritization of, and commitment to, the restoration of degraded land, such as CBD Aichi targets and numerous national and international restoration programs and initiatives. This has led to an explosion in the number of projects and scientific publications in ecology restoration. At the same time, we see a shift in focus on the outcomes of restoration, from biodiversity to the production of ecosystem services, and of the extent to which projects prove to be cost-effective.
Within this frame there are two issues of particular relevance, a) the need for larger projects where restoration is put into action to achieve the international and national targets, and b) the necessity to involve new actors and all types of knowledge for this to be successful. Large landscape restoration projects need to take the (potential) buzzwords “cooperation”, “involvement” and “local knowledge” seriously, and find pragmatic solutions for implementing scientific knowledge into action. Based on this we believe that large restoration projects provide new and relevant knowledge for the future management of degraded land.
In this symposium, we will present four large projects from Estonia, Iceland, Norway and Scotland. They take place under different socio-economic conditions and in different ecosystems. The projects presented are at different stages of implementation. All have, however, experienced the possibilities and the challenges of bringing restoration to the management of large areas, and therefore provide valuable lessons for future restoration projects.

### S-4.2

**Forest ecosystem restoration on post-mine oil-shale quarries in Estonia**

Diana Laarmann, John Stanturf, Henn Korjus, Andres Kiviste
Estonian University of Life Sciences, TARTU, Estonia

Forest ecosystem restoration on post-mine oil-shale quarries in Estonia
Associate Professor Diana Laarmann, John A. Stanturf, Henn Korjus, Andres Kiviste

Oil-shale mining has been carried out in Northeast Estonia since 1916. Most of the surface mining sites were located in former woodlands. Although the forest ecosystem was destroyed and surface and underground water regimes extensively altered, reclamation of abandoned mining areas has been applied since 1960. Scots pine (*Pinus sylvestris* L.) was the main species for afforestation.
This study presents results from 74 permanent plots on two closed (Aidu and Viivikonna) and afforested oil-shale quarries in Estonia. The stand ages vary between 15-45 years. All plots were reclaimed by Scots pine, except for eight sample plots that were replaced naturally by Silver birch (*Betula pendula* Roth.).
Complex monitoring of forest stands, ground vegetation and soil was carried out in 2016. Before planting there were no soil cover at all. Average soil thickness is now 6 cm. Soil is alkaline; pH varied from 6.1-7.7. Soil thickness influences tree height and diameter growth. New suitable habitat is forming for threatened herbaceous species.
Restoration of post-mining sites often leads to development of novel ecosystems, their functions and composition

may be valuable and serve restoration goals.

**S-4.3**

**Hjerkinn PRO - the restoration of a high mountain military training area into National Park**
Pål Skovli Henriksen
Forsvarsbygg, HAMAR, Norway

*Hjerkinn PRO* is a large-scale restoration project in high mountain landscape in Dovrefjell, Norway. The area was used as a military training area and shooting field between 1923-2008. In 1999, the Norwegan Parliament decided to establish a new military shooting field in south Norway, and also close down Hjerkinn. Due to the nature values in the area, the decision was linked to a comprehensive plan for extended protection of Dovrefjell. The purpose is especially to protect an intact high mountain ecosystem and a beautiful and distinctive landscape with rich animal and plant life. The wild reindeer at Hjerkinn is considered one of the last stocks of the most original wild European reindeer.
The main strategy for restoration of Hjerkinn shooting field, is to revers all technical infrastructure, and prepare for natural recovery of vegetation and landscape. In some areas planting and seeding has to help boost the process. This is continuously coordinated with the other important part of the project; clearing of unexploded ammunitions. The area has also been used for tourism, hunting and grazing for decades, and a significant part of the project has been to balance local interest with national demand of protection. The protection plan was decided by the Norwegian government in April 2018. Most of the area is protected as a National Park, but some infrastructure will be kept for future access of local farmers and a tourist shuttle bus. Main challenges in the restoration project has been to establish feasible and economic successful restoration methods for a high mountain area, and to secure the successful execution of the partnership between the project management, biological advisors and entrepreneurs. Understanding the local society and finding the right balance between future use and protection has also proven a challenging journey.

**S-4.4**

**The Heklusk**ó**gar project in Iceland: Restoration of birch woodland in a severely degraded landscape**
Asa L. Aradottir[1], Hrönn GuÃ°mundsdóttir[2]
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The Hekluskógar project aims to establish native birch woodlands in a severely degraded area near the active Mt. Hekla volcano in S-Iceland. Its main goals are to enhance resilience of nearby ecosystems to volcanic ash deposition, and to prevent secondary distribution of ash by wind and water. This entails restoring ecosystem functions and biodiversity that contribute to numerous ecosystem services; from carbon sequestration to improved options for future land use.
The Hekluskógar area extends over 900 $km^2$ with a current project area of 620 $km^2$. When the project started in 2007, more than half of this area had very active soil erosion and sparse vegetation cover. Low nutrient levels and water holding capacity, together with unstable surfaces due to erosion and cryoturbation characterize the eroded areas. Other parts of the Hekluskógar area have more favorable conditions and even a few remnants of the extensive woodlands that once covered much of the area.
The main strategy for woodland restoration in Hekluskógar is to use natural regeneration of birch to the extent possible. In much of the area, however, this is hindered by unfavorable conditions for seedling establishment and lack of seed. Interventions to overcome these limitations include revegetation to stabilize the soil surface and create safe sites for seedling establishment, together with planting or seeding of “woodland islets” that will later serve as local seed sources. The implementation phase of Hekluskógar is expected to take at least 30 years but the full extent of the resulting woodlands will not be realized until many decades later.
A project manager runs the daily activities of the Hekluskógar project, but various groups have been engaged in the project’s implementation. This includes contractors and governmental agencies, local landowners, summerhouse owners, private and NGO volunteer groups and students.

**S-4.5**

**Cairngorms Connect - the 200 year vision of the UK's biggest habitat restoration project**
Jeremy Roberts
Royal Society for the Protection of Birds, NETHYBRIDGE, United Kingdom

*Cairngorms Connect* is a partnership of neighbouring land managers in the Scottish Highlands, committed to a bold and ambitious 200-year vision to enhance habitats, species and ecological processes across 600 square kilometres within the Cairngorms National Park.
In UK terms, this is a landscape of superlatives: Ancient woodlands intersected by sparkling rivers and lochs, encircle an Arctic-like mountain massif – the most extensive and wildest of its kind in Britain; there are vast tracts of blanket bog, tranquil wetlands and secret woodland bogs. It is a place where eagles soar, wildcats prowl and red

squirrels forage; home to plants, insects, birds and mammals found in few other places.
Yet the project area has suffered centuries of damage: forest bogs are crossed by drains and planted with non-native conifers; domestic animals and artificially high deer populations have caused landscape-scale suppression of our forests and erosion of our blanket bogs; centuries of engineering works have confined rivers to artificial channels, and many rare and iconic species are restricted to fragments of suitable habitat. The strength of *Cairngorms Connect* is the coming together of like-minded managers committed to reversing this damage, delivering habitat enhancement and expansion at a scale unparalleled in Britain.
This ambition also brings challenges: How do we ensure common cause across the partnership? How do we bind commitment for 200 years? What are the practical challenges of working at this scale? How do we transcend centuries of Highland management practice, to introduce an alternative model for the UK's uplands? How do we secure stakeholder buy-in; from those we employ, to those who live, work and recreate here? How do we promote what we value and restore, without increasing the risk of damage by those who come to experience this spectacular place?

**W-2 Enhancing the SER Standards for a Changing World**

Chairs: Jim Hallett and James Aronson

Workshop summary:
The SER Standards for the Practice of Ecological Restoration establish benchmarks for designing, evaluating, and promoting successful restoration projects from an ecological perspective while respecting socio-cultural realities and needs. We will discuss ongoing efforts to test, refine, and strengthen the Standards to operationalize them for restoration projects and programs worldwide

**W-3 Restoring river connecectivity : challenges and current development**

Chairs: Joshua Jones and Peter Jones

Workshop summary:
In this workshop, participants will have the opportunity to share ideas and discuss key requirements and challenges for achieving the restoration of longitudinal river connectivity including barrier identification, barrier removal, impact mitigation methods, and monitoring adaptive management. This will allow sharing of perspectives; strengthen the global network of those working to improve river connectivity; and advance collaborative efforts to improve the success of river connectivity restoration efforts worldwide.

**S-5 - Grassland restoration in Europe: current status & future prospects, cont.**

**S-5.1**

**Standards as a basic tool for ecological grassland restoration in the Czech Republic**
Ivana Jongepierova[1], Marie Straková[2], Magdalena Ševcíková[2], Karel Prach[2]
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In the Czech Republic (except for the White Carpathian Mts.) regional seed mixtures nor species-enriched commercial seed mixtures are yet used for the restoration and recreation of grassland with non-productive functions. In order to facilitate the use of these mixtures on a larger scale, the Czech Nature Conservation Agency has issued two standards (*Restoration of grasslands using regional seed mixtures*, 2014 and *Grassland*, 2018).
The first one contains instructions for the application of different methods aimed at ecological 'regrassing' of arable land and the support of species diversity in grasslands recently created with commercial seed mixtures. It includes a map of provenance regions in the Czech Republic.
Since regional seed mixtures are not yet available on the Czech market, the other standard is a compromise between the use of commercial seed mixtures and regional ones. It prescribes to include into species-enriched seed mixtures only plant varieties of Czech or Slovak origin reproduced in the Czech Republic and prohibits the use of interspecific and intergeneric hybrids. Sowing of *Festuca arundinacea* in the landscape is not allowed, except for justified cases of sites regrassed for technical purposes and sites where this species is naturally distributed.
These standards are designed for all those dealing with grasslands in the landscape. The guidelines are aimed at stimulating the production and use of proper seed material in grassland restoration in the entire Czech Republic.

**S-5.2**

**Landscape genetics as a perspective tool for guiding grassland restoration: a case study from Estonia**
Sabrina Träger, Iris Reinula, Aveliina Helm, Tsipe Aavik
University of Tartu, TARTU, Estonia

Loss and isolation of habitats are major threats to genetic diversity, the latter being a crucial prerequisite for species survival in times of rapid environmental change. Yet, we still lack detailed understanding of how landscape elements shape functional connectivity between habitats and by that affect the distribution of genetic diversity in habitats with high conservation value threatened by the effects of area loss and isolation. Particularly, semi-natural grasslands have experienced drastic decrease in area and connectivity due to changes in management strategies, resulting in loss of genetic diversity. The introduction of genetic tools to conservation biology is not new, but landscape genetic studies combining genetic and landscape analysis are still scarce despite their comprehensive examination of the connection between landscape heterogeneity and genetic diversity. Moreover, recently, novel efficient genetic screening methods for studying genetic diversity, e.g. restriction-site associated DNA sequencing (RADseq), have been developed enabling the detection of numerous molecular markers distributed over the whole genome allowing the analysis of the adaptive potential of species. We applied RADseq to collect thousands of single nucleotide polymorphism (SNP) markers across 740 individuals originating from 41 populations of *Primula veris*, a plant species common to semi-natural grasslands, to evaluate the effect of grassland fragmentation on the genetic diversity of *P. veris*. Our study systems are Estonian alvar grasslands because of their high conservation value due to exceptional species diversity and unique species composition, but which have experienced drastic loss in area and connectivity in the last century. We also investigated whether the lack of management and consequent overgrowth with woody vegetation affects the genetic diversity and related adaptive potential of *P. veris*. Our study shall shed light on the fundamental landscape-driven genetic background of plants, which can serve as a basis for guiding decision-making in restoration ambitions and environmental conservation policy.

**S-5.3**

**Ecological restoration of grasslands in cities as components of green infrastructure: ecological and social aspects**

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Urban green infrastructure includes gardens, parks or green roofs as well as remnants of natural and semi-natural ecosystems. In times of decreasing biodiversity and ongoing climate change urban green infrastructure provides habitats for species, which have become rare in agricultural landscapes, and it ensures important ecosystem functions such as water retention and cooling. In Central Europe, grasslands in urban or suburban areas are often species poor due to high management intensity or because they have been established with species poor mixtures of grass cultivars.
Currently, many local initiatives in Germany have started to restore grasslands to help bees and other flower-visiting insects. We studied the effects of seeding typical native grassland species of regional origin on species richness and species composition of urban grasslands established by different stakeholders in northwestern Germany. Seeding of species-rich seed mixtures (23-39 species) after severe soil disturbance always led to an increase of vascular plant species richness compared to unsown control plots. The number of sown target species on restoration sites and their establishment rates were significantly positively correlated with soil pH. In contrast, increasing soil moisture tended to have a negative effect on the establishment of the mostly mesophytic species of the seed mixtures.
Our results highlight the importance of taking into account local environmental conditions of restoration sites more in detail before start of the restoration in order to apply site-specific seed mixtures with well adapted native species. As the ecological knowledge of local initiatives is often not sufficient to study site conditions and to choose the right species, we recommend developing strategies for knowledge transfer. Until this has been effectively done, we suggest to use species-rich seed mixtures with more than 35 species when restoring urban grasslands and to include regionally typical native species covering a broader spectrum of environmental conditions.

**S-5.4**

**Restoration of a habitat for resource-conservative plants by resumed cutting of an abandoned grassland**

Andreas Stampfli[1], Michaela Zeiter[2]
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Biodiversity conservation in fragmented landscapes may include proper management of underused, degraded habitats in the neighbourhood of semi-natural grassland to extend the resilience of local populations to threats from global change. We resumed cutting in an abandoned grassland to restore a semi-natural meadow as a habitat for slow growing, resource-conservative plant species in close vicinity of an old species-rich hay meadow at Pree, Monte Generoso, Switzerland. Ten years of resumed cutting resulted in little change in the species composition of the formerly degraded grassland, the dominant grass *Brachypodium pinnatum* showed high persistence. Dispersal limitation and a lack of target species in the soil seed bank were identified as further key issues. We hypothesized that continued cutting and removal of the harvest will reduce productivity in the long run and enhance slow growing species with more conservative resource economies at the expense of *B. pinnatum*. Here, we compare 20-year trends in species richness and community-weighted means of specific leaf area (CWM SLA) between a 1-$yr^{-1}$ and a 2-$yr^{-1}$ cutting regime in the formerly abandoned site. After 20 years of cutting we compare the species composition of the former abandoned meadow with the species-rich target meadow based on ca. 900 point-quadrats in areas of 36 $m^2$. Community productivity strongly declined in the second decennium after resumed cutting. Concomitantly *B.*

*pinnatum* declined in abundance and resource conservative (low SLA) species slowly recolonized the grassland. Cutting twice per year during the first decennium resulted in a stronger decline in CWM SLA than cutting only once per year. Abandonment followed by cutting for twenty years clearly declined productivity to levels below the long-term average of an old semi-natural meadow due to species loss, dispersal limitation and the collapse of the dominant grass.

**S-5.5**

**The restoration of Nardus grasslands by soil inoculation**
Willem-Jan Emsens[1], Arrie Van der Bij[2], Roland Bobbink[2], Roos Loeb[2], Rudy Van Diggelen[2]
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*Nardus* grasslands are low-productive and often species-rich grasslands that occur through much of Europe, with highest cover in Alpine regions. In lowland Europe, the habitat has usually developed after centuries of human management such as frequent haymaking. The area of the habitat has declined over the past few decades due to land use conversion and intensification, tree encroachment, eutrophication and acidification. Concern over the future of the habitat has resulted in its legal acknowledgment as a priority Natura2000 habitat type by the European Commission (H6230).
An increasing number of *Nardus* grassland restoration projects have been launched. The primary aim is typically to decrease soil nutrient pools, e.g. by phosphorus mining or topsoil removal. However, these measures not always seem adequate, and the development of *Nardus* grasslands may falter even on potentially suitable and nutrient-depleted soils. Studies from other habitat types (e.g. heathlands) have shown that dispersal limitation of target species can be a significant bottleneck, which steers vegetation assembly in the direction of dominance by a few common and widespread species. Dispersal limitation can be lifted by targeted (re-)introductions, e.g. by seeding or by hay transfer from well-developed reference grasslands. Another promising technique in grassland restoration is the inoculation of top soil fragments or sods from reference grasslands, which introduces seeds but also relevant microbial communities.
We present results from a set of experimental case studies on *Nardus* grassland restoration in the BeNeLux. Key to these studies was the identification of biogeochemical bottlenecks for *Nardus* grassland restoration, as well as finding ways to speed-up restoration. We discuss the feasibility of several techniques, and evaluate their applicability on a larger scale.

**S-6 - Adapting dryland forest & woodlands to climate change: lessons from past reforestations to the future**

**S-6.1**

**Using microclimate scale to direct reforestations in drylands**
Adriana Príncipe[1], Pedro Pinho[1], Alice Nunes[2], Cristina Branquinho[1]
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Mediterranean Basin will be one of the areas most affected by climate change, e.g. with more frequent droughts and occurrence of extreme events. Afforestation is an important nature-based solution for climate change adaptation. Revegetation efforts are often unsuccessful, particularly in roughness areas, because microclimate is ignored even when macroclimate is taken into consideration. The objective of this work is to provide a tool to guide revegetation efforts in roughness drylands using macro and microclimate. We used two types of remote sensing data: satellite images and aerial photographs (from 1950 to the present) to quantify the spatial-temporal changes in tree cover along a climatic gradient in the south of Portugal (c. 35.000 $km^2$). Results show that both macro and microclimate influence tree cover, an indicator of the revegetation success potential. A model was then developed and used to map with high spatial resolution the revegetation potential in the study area. Using this model predictions, we can point the areas where natural tree regeneration is possible without further management besides ensuring grazing exclusion during an adequate period, and the areas where assisted afforestation techniques are necessary. These results are used to increase the precision of (re)afforestation planning and its success, thus contributing to create resilient and sustainable forests which can bring new solutions for dryland landscapes under a climate change scenario.

**S-6.2**

**Long-term effects of afforestation projects on soil properties in two contrasted Mediterranean areas**
Estela Nadal-Romero[1], Jeroen Zethof[2], Teodoro Lasanta[2], Erik Cammeraat[2]
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Most Mediterranean areas have been subjected to significant human pressure through deforestation, cultivation of steep slopes, fires and overgrazing. However, during the 20th century, especially in the 1960s and 1970s, these areas were affected by rapid population migration and abandonment of cultivated fields. The idea of land

degradation after abandonment was widespread, motivating extensive afforestations that were conducted by national forest services all over the Mediterranean Region. However, very few evaluations of the effect of afforestation policies in Mediterranean areas have been carried out in an integrated way. This study examines the effects of afforestation and secondary succession on soil quality in two contrasted areas: (i) a semiarid area located in southeastern Spain, and (ii) a humid area located in the Central Spanish Pyrenees. In both areas, a mosaic of different land uses and land covers were selected, including natural forest, natural revegetation (secondary succession) and afforestation sites. Composite samples were taken to analyze the physical and chemical soil properties.
Different results have been observed in the study sites: in the semiarid area, 40 years after afforestation the restoration of the natural soil functioning seems to be successful and secondary succession only induce small changes; conversely, in the humid area, no differences have been found between the soil improvements by secondary succession in comparison to afforestation. These results highlight that success of afforestation projects should be evaluated for every study case, and site specific solutions should be considered.
Acknowledgments: This research was supported by a Marie Curie Intra-European Fellowship in the project “MED-AFFOREST” (PIEF-GA-2013-624974) and the ESPAS project funded by the MINECO-FEDER (CGL2015-65569-R). Estela Nadal-Romero was the beneficiary of a “Ramón y Cajal” postdoctoral contract (Spanish Ministry of Economy and Competitiveness).

**S-6.3**

**Recovery of ecosystem services through restoration in Mediterranean woodlands depends on previous degradation and aridity**
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Degradation in dryland woodlands may lead to losses in ecosystem functioning and diversity that can be very difficult to recover. Based on the assessment of seven sites distributed across the northern Mediterranean and representing a range of degradation drivers and environmental pressures, we investigated how the degree of recovery of ecosystem services through restoration relates to the accumulated loss of ecosystem services that resulted from degradation. For each site, we identified areas representing healthy (reference) and degraded states, as well as restored areas where corrective measures had been conducted in the past. We assessed a suite of structural and functional indicators, from which we estimated values for the provision of a balanced basket of ecosystem services. The potential for restoration was derived from the comparison between the degraded and restored states, while differences between reference and degraded sites were used as indicators of degradation severity. Despite the between-site variability in restoration treatments and in the time elapsed since their application, the degree of ecosystem services provision achieved by restoration exhibited a global positive relationship with the relative degree of degradation observed, so that the higher the loss of services the higher their provision in the restored areas. However, this positive trend shifted for the driest and most degraded site, which kept very low levels of ecosystem services provision in the restored areas, despite the success of the reforestation applied in terms of survival and growth of the introduced plants. Overall, our results suggest that that the relationship between restoration potential and degradation level follows a non-linear model, being positive until certain threshold in the loss of services, beyond which the benefits of restoration drop sharply. The implications of these results are important for prioritizing restoration efforts and assessing the cost-benefit of restoration as a function of degradation.

**S-6.4**

**Evaluating reforestations in drylands as an adaptation measure to a climate change scenario**
Melanie Köbel[1], Alice Nunes[1], Adriana Príncipe[1], André Vizinho[1], Helena Serrano[1], Cristina Soares[2], Pedro Pinho[1], Cristina Branquinho[1]
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Forests contribute for carbon sequestration, preserve soils, promote water infiltration and resilience in face of extreme events (heat waves, torrential rains, etc.), while providing natural resources. In drylands in particular, increasing forest area via reforestation is a common practice to revert land degradation, increase ecosystem resilience and services provision. In Portuguese drylands, reforestations have been extensively made in the past decades to promote ecosystem services such as soil quality and tree productivity. Moreover, climate change scenarios suggest that aridity will increase in this region, to which reforestations can be an important mitigation and local adaptation measure, but the increasing water-limitation trend demands that good practices are applied, to ensure optimal success of reforestations and their long-term sustainability. However, evaluation of reforestations is traditionally limited to assessments of tree mortality and density, and lack to consider other ecosystem properties. In this work, we assessed reforestations across a regional scale, comprising 44 sites with different aridity levels and tree species (among holm-oak, cork-oak and umbrella pine, in single-species or mixed plantations). We assessed several ecosystem properties related to the delivery of services and to ecosystem functioning, such as tree density, pasture productivity, biodiversity, potential for natural regeneration and soil organic matter, and related these with climatic drivers and reforested species. We found that some ecosystem properties are related with the species planted, such as pasture productivity, while others are primarily related with climate, such as soil quality. With this

project, we also published an e-book to foster discussion on planning and implementation of reforestations taking into account current and predicted climate change scenarios, and population's expectations.
Acknowledgement: Programa AdaPT, financed by EEA Grants and Fundo Português de Carbono and project PTDC/AAG-GLO/0045/2014, funded by FCT-MEC.

**S-6.5**

**Effects of afforestation programmes on catchment hydrological response and water production among the 2050 horizon**
Estela Nadal-Romero[1], Makki Khorchani[2], Noemi Lana-Renault[2], Javi Zabalza[2], Christina Tague[2], Janet Choate[2], David Regüés[2], Teodoro Lasanta[2]
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Since the beginning of the 20th century afforestation programs in abandoned and degraded areas have been conducted in Mediterranean mountain areas. However, the effects of afforestation projects on water resources are still controversial. In this study we analyze and compare the hydrological response of three different vegetated areas in the Central Spanish Pyrenees: a natural forested area (San Salvador catchment), and two catchments representing farmland abandonment scenarios: a natural re-vegetated area (Arnás catchment), and an afforested area (Araguás_Afforestation catchment). The results show significant differences in the hydrological responses of the two post land abandonment scenarios and the natural forest area, indicating that vegetation and soil properties (resulting from past agricultural activities) can influence the hydrological response and the runoff generation processes.
In addition, this study implements the Regional Hydro-Ecological Simulation System (RHESSys) to simulate streamflows in the three catchments. Different scenarios combining changes in land cover and in climatic variables are considered to study the effects of land use changes and afforestation programs on water production in a context of Global Change.

**O-4 - Restoration & Climate change, cont.**

**O-4.1**

**Stability of soil carbon storage in afforested lands**
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Land restoration by afforestation increases soil organic carbon (SOC) storage relative to a treeless land. Although this climate-beneficial land-use change raises SOC levels and therefore the soil's capacity to reduce atmospheric CO2, it is not clear whether the protection of SOC against decomposition, leaching, and erosion is improved as well. Given that changing environmental conditions may threaten the integrity of SOC reservoirs, understanding SOC stability following afforestation is relevant to the long-term maintenance of SOC under global changes.
We reviewed the literature investigating the effect of afforestation on the proportional changes of carbon stored in soil size-density fractions and in soil aggregates, which are robust indicators of long-term SOC stability. Too few studies reported data on biochemical-recalcitrant fractions to be considered in our analysis. The only variable that could relate to SOC recalcitrance was the carbon-to-nitrogen ratio. Based on 30 publications encompassing over 100 sites, our review shows that the conversion from a treeless land (i.e. cropland, grassland, pasture or degraded soil) to a forested land (i.e. plantation or natural forest succession) increases the contribution of the more labile light fraction (LF) and particulate organic matter fraction (POM), more so than that of the more stable, mineral-associated silt and clay fraction (S&C). Afforestation also increases the carbon stored in macro-aggregates more often than in micro-aggregates and rarely in the free S&C. Afforestation usually decreases the carbon-to-nitrogen ratio of SOC. Overall, although the SOC formed in forests is likely more recalcitrant, of lower biochemical quality, the new carbon incorporated into the soil in afforested land is preferentially stored in more labile soil fractions, in line with the Microbial Efficiency-Matrix Stabilization framework predicting preferential SOC stabilization in mineral fractions from high-quality litter.

**O-4.2**

**CO2 and methane exchange of soils, trees and ditches in drained and rewetted, temperate fens**
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Drained fens frequently show high carbon dioxide emissions. Rewetting is a common measure of restoration, yet it can cause high methane emissions which counteract the initial intention of climate change mitigation. In recent years, high emissions from structural elements like ditches and tree stems also gained attention. While plantations of black alder (Alnus glutinosa (L.) J. Gaertn.) can improve the uptake of carbon dioxide, they can also act as a source of methane. Due to the often anoxic conditions and high availability of substrate, ditches can also be a strong source

of methane and carbon dioxide. However, data on the emissions of trees and ditches is still scarce for the temperate region. Here, we present data on the exchange of methane and carbon dioxide from the soil, tree stems and ditches in six temperate fens from the first measurement year of a three-year measuring period. The study sites comprise three different kinds of fens including percolation fens, coastal fens and forested fens of which there is a drained and rewetted one for each type. In all study sites, we use non-steady-state manual chambers to measure gas exchange at the soil surface. We additionally asses the gas exchange at the stem surface of black alder (stand age: ~40 years) in one drained and one rewetted alder plantation. Additionally, we study the heterogeneity of stem exchange among different trees and different heights in regular campaigns. To quantify gas emissions from ditches we use floating chambers and bubble traps in two non-forested sites. In this way, we aim to evaluate the relative share of stem and ditch emissions compared to those of soil and herbaceous vegetation. At the same time, we show the wide range of greenhouse gas exchange values that can occur in temperate fens across fen types and hydrologic conditions.

**O-4.3**

**Climate change modifies carbon sequestration in copper-polluted forest soils**

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Soil carbon (C) storage is a key ecosystem function which can provide globally important services such as climate regulation. The effect of climate change on the restoration of soil C storage potential on post-mining land, where the development of both soil and vegetation starts *de novo*, is still insufficiently understood.

In this work we discuss how the recent changes of climate, effectuating temperature increase and overall habitat xerophytization have, during about 40 years, markedy modified the course of spontaneous succession and concomitantly the soil C sequestration potental in a model floodplain severely altered by long-term deposition of sulphidic waste from a copper (Cu) mine. Excessive Cu strongly reduces turnover of soil organic matter and adversely affects the revegetation process. Natural floods in this complex geomorphic setup on the other hand bring both pollutants and deficient nutrients to the affected floodplain. As the recent climate changes reduce the intensity of natural floods, two very different but highly specialized forest types are developing along the microelevation gradient (transects perpendicular to water channel) with up to 3-fold different topsoil C sequestration.

This work shows how climate change can increase the vunerability of spontaneous restoration process primarily by reducing nutrient fluxes.

**O-4.4**

**Enrichment Plantation Does Not Increase Carbon Sequestration in The Exclosures in The Highlands of Ethiopia**

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In order to foster the potential of exclosures to sequester carbon, they are increasingly assisted through enrichment planting in Tigray, north Ethiopia. To study the impact of the enrichment planting on carbon sequestration, five exclosures with enrichment planting and five pure naturally regenerated exclosures were selected. Along parallel transects, all woody vegetations were counted and measured for their diameter and total height on 20m X 20m plots. Soil samples were collected at depth of 0-0.2m on five subplots, one at the center and four at each corner of the plots. To test significant differences of carbon stored, general linear model, multivariate analysis was run in SPSS20. Significant differences in organic soil carbon, above ground and total carbon between naturally regenerated and enriched exclosures ($p=0.00001$) were found. Lower altitudes had significantly higher soil organic carbon ($P<0.05$) than the higher altitudes. However, insignificant effect was found from slope on carbon distribution. Enriched exclosures performed more poorly in carbon sequestration, against the expectation. This was possibly due to the disturbances caused by mass plantation and poor post plantation follow up, as an improved performance ($P < 0.05$) in one enriched exclosure against its natural regenerated counterpart was confirmed to receive better management practices. This suggests that differences in management practice affect the success rate of enrichment plantation. In dryland areas where growing conditions are limiting and post planting management is poor, success and efficiency of enrichment planting is low. Costs incurred for enrichment planting schemes are then not well justified both in terms of growth success and accumulation of carbon in exclosures.

**O-4.5**

**GPP estimation using UAVs and field methods**

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Current approaches to measure GPP use accurate measurements of eddy covariance towers or carbon flux chambers. Such approaches are highly accurate, but are costly and hard to scale on spatial terms. To expand the assessed area and reduce the costs, remote sensing techniques have been used to derive carbon sequestration from light use efficiency (LUE) models. Spatial modeling of carbon sequestration uses images and light sensors to derive Gross Primary Production (GPP). Modeling GPP has been successfully used to account for carbon sequestration, using satellites and field sensors. This approach will be tested during the summer of 2018 on the field study at Skeiðarársandur (Iceland), surveying 5 different areas with different vegetation succession states, i.e. entirely colonized by birch to a bare presence of birch. A set of field sensors will be placed at the study area, i.e. soil temperature and moisture probes, photosynthetic active radiation (PAR) sensors, sun radiation sensors and a data loggers. Additionally, GPP measurements will be conducted with hand-held devices, in order to calibrate the final model. A flight with drone will be performed three times during the summer. Each flight will output multispectral (Red, Near Infrared, Red Edge, Green) and long-wave infrarred (Thermal) datasets. Derived VI's will be used to model GPP, by adjusting NDVI to the PAR sensed in the field. Furthermore, two limiting factors will be used for adjusting the final GPP, i.e. soil temperature and soil moisture. The moisture will be derived from the parametrization of NDVI to soil temperature, adjusted by soil sensors. The end result will be the estimation of GPP during the sensing period, which will be represented by an image covering the surveyed area, representing the kgC sequestered or emmitted. The ongoing work, datasets and methods for the project will be presented on SER2018.

## O-5 - Forest/woodland restoration

### O-5.1

**A century of restoration of birch woodlands in the Þórsmörk area**

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The area of Þórsmörk ("Thor´s forest") is a woodland nature reserve, located in a valley and mountain range north of Eyjafjallajökull and Mýrdalsjökull glaciers in South Iceland. Formerly, the whole of the Þórsmörk area was covered with birch woodlands that were utilized for centuries as a source of fuel wood, building material, charcoal and whole year livestock grazing. By the early 19th century, most of the area was deforested. Furthermore, the soils had begun to erode as a result of deforestation and overgrazing. An inventory of woodlands carried out in the area in 1899, showed that shrubby woodland patches remained in the area, threatened by grazing and erosion.
Local farmers waived their grazing rights and handed the area over to the Icelandic Forest Service in 1920. In the following years, the area was fenced off to exclude sheep grazing. Over the following decades, the birch cover expanded into treeless areas and the older forest remnants grew taller. Eroded areas were reclaimed with fertilizer application and grass seeding which facilitated natural regeneration of woodland. A recent assessment of the woodlands in the Þórsmörk area showed that the birch cover had multiplied, with additional scattered trees covering nearby areas. This expansion of woodlands is one of Iceland´s most successful restoration projects in Iceland and it will be presented in the talk.

### O-5.2

**PLANT REPRODUCTIVE TRAITS IN OLD AND RECENTLY-RESTORED TEMPERATE FOREST UNDERSTORIES**

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Recently-restored forests on former agricultural land have impoverished herbaceous understories. This is partly due to the poor colonizing capacity of understory plants, which makes them slow in responding to land use change. Functional traits can be used to compare old and recent understories, informing about which plant syndromes are missing after a restoration effort. In this work, we focus on the seed and germination traits of herbaceous understories, investigating how they influence community assembly in restored woodlands.
Our study took place in temperate deciduous oak forests; in two locations at the centre and southern limit of the European Atlantic region (Loder Valley Nature Reserve, UK; and Tragamón Oak Grove, Spain). In each location, we sampled a pair of old and recent forests. In each of the four forests, we established ten permanent plots, where we surveyed understory species abundances every two months for one year. We recorded plant reproductive traits for the species found in the plots, and measured germination traits in laboratory experiments with seeds collected *in situ*. Finally, we calculated community-weighted means (CWM) for each trait and plot.
The reproductive traits of old and recent understories had significant differences in both locations. Old forest communities had shorter plants that flowered earlier and were more dependent on vegetative reproduction. They produced less seeds, which were heavier and had higher terminal velocity. The germination of these seeds occurred at colder temperatures and was less dependent on light. These results highlight the importance of reproductive traits in driving community assembly; and indicate which species traits should be prioritized by understory reintroduction

efforts.

**O-5.3**

**Spontaneous stand regeneration and herb layer recovery in post-fire woods 16 years after a fire**
Anna Orczewska[1], Malgorzata Zaczek[2], Katarzyna Zolna[2], Marcin Prukop[2]
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Due to prolonged periods of dry and hot summer weather, temperate deciduous forests are increasingly affected by fires. Since they lack evolutionary adaptations to fire, such events are regarded as severe disturbances, detrimental to their biodiversity. They lead to high plant mortality and the loss of organic matter. Forest recovery process of such sites is very slow. We compared the structure and regeneration of naturally developed, 16-year-old post-fire, unthinned and thinned stands and the recovery of their herb layer in southern Poland, where in summer 1992 the area of 9,062 hectares was affected by fire. We measured tree heights and diameters within each of the ten 40 x 20 m plots and within ten transects (10 m long by 2 m wide, consisting of 5 quadrats) we counted the number of tree and shrub seedlings. We studied the herb layer composition in randomly located 10x10 m plots (61 in managed and in unmanaged forests). Finally, we surveyed the migration rate of forest species to post-fire woods along the burned-unburned forest ecotones. The effect of thinning on stand composition and on the number of trees was significant; in thinned forests stand was exclusively composed of birch, whereas in unthinned six other tree species were recorded. The response of stand to management was also detectable in its regeneration process, which was more dynamic in unmanaged forest and in the herb layer composition, which contained more shade-demanding woodland species in unthinned forest. The recolonization of herbaceous layer by forest species was faster in forests that lack management in their stand. Recovery of woodland species into post-fire woods is the combined effect of regeneration and secondary succession, based on autochthonic and allochthonic propagules, respectively. Local depressions, providing refuges for fire-sensitive, dispersal-limited species, contribute to survivorship and recolonization of herb layer after a fire.

**O-5.4**

**Neighborhood effects on early survival and growth of restored woody plant communities**
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The effects of the neighboring vegetation on plant performance have been shown to widely vary in strength and nature. In the context of restoration practices, understanding these effects could be essential for the success of the project, especially under the stress brought up by climate change. In this study, 14,668 plants from 16 woody species were planted as part of reforestation effort in a mine contaminated site. Planting protocols differed in density (planting distances of 1, 1.5, 2 and 2.5 m) and in community composition (xerophyte, intermediate and hydrophyte mixtures). Ten months after planting all plants were censored and mapped, together with the vegetation naturally occurring around the plots. For four years, plants of six species were monitored for survival, status (amount of damage) and size (height, crown area and basal diameter). We used these data to estimate survival as a function of planting density and status, and growth as a function of status and the neighborhood surrounding each plant (plant density and species identity).
Results show that survival was high across species and planting densities, although plants that were severely damaged had lower survival. For most species, this decline increased with planting density. In a particular year, relative growth rates increased with the level of damage reported the previous year, indicating a healthy level of resilience at this point of the restoration. The effects of neighbors varied across species, but as expected, they increased with plant density. Effects were always positive for *Phillyrea angustifolia*, always negative for *Crataegus monogyna*, varying with the measured variable for *Myrtus communis* and *Olea europaea*, and neutral for *Pistacia lentiscus* and *Tamarix africana*. Outcomes from this work point at the importance of taking into account the neighborhood environment in restoration practices, as this could ameliorate or exacerbate the impact of climate change.

**O-5.5**

**Potential of prescribed fire as a restoration tool for oak regeneration in temperate Europe**
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Oak-dominated ecosystems are of great importance for biodiversity. However, issues with natural regeneration have caused concern in Europe and North America for over a century. In eastern North America, a fire-oak hypothesis has been developed which attributes some oak regeneration problems to effective fire suppression. Prescribed burns are now used to restore and regenerate oak-dominated ecosystems, often combined with thinning to increase light and control competing vegetation. In temperate Europe the role of fire is not clear, but fire suppression is

widespread. This study investigates if the fire-oak hypothesis can be applied to European temperate oaks (*Quercus robur* and *Q. petraea*). A field experiment combining effects of light (high-low), browsing (fence-no fence), and fire (burn-no burn) in a complete block design with eight treatment combinations was established in five oak-dominated forests in southern Sweden. Light and fence treatments were established in spring 2016, and a low-intensity burn was simulated using a gas burner at the end of that growing season. We have recorded survival and relative growth of 2357 naturally regenerated oak seedlings. The growing season following burn treatment, survival of oak reproduction ranged from 67% in low-light*fence*burn-treatment to 96% in high-light*fence*no burn-treatment. For all burn treatments, 92% of the surviving oaks had re-sprouted. Relative height growth was greatest in high-light*fenced treatments, irrespective of the burn treatment. To our knowledge, this is the first field study to investigate use of a low-intensity prescribed fire as a restoration tool for regenerating European temperate oak forests. The initial results are positive in that we demonstrate the high sprouting capacity of naturally established oak seedlings that experienced a low-intensity prescribed fire. Our results also highlight the importance of investigating combined effects of multiple factors. Continued research will further explore the response of oak reproduction to the interactive effects of light, browsing, and fire.

**O-5.6**

**LOST IN THE WOODS! A POLITICAL ECONOMY OF THE FOREST SECTOR REFORM IN UGANDA**

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Uganda entered audacious forest reforms in the 1990s, as part of the state reconstruction after the turbulent Amin/Post-Amin period. The reforms came during general and partly donor driven structural reforms under the Museveni regime, and brought major changes in all aspects of the forest sector including policies, institutions, organisations and governance systems. This was implemented from 1998-2004 and it is now possible to critically asses its performance. We use a political economy lens to analyse the institutional aspects, political contexts and motivation of the reforms and their implementation trajectories. The findings reveal that the reformed forest sector is performing badly and has provided venue for major political interventions and corruption. Half of the forest cover has been lost since the inception of the reform. Main organizations are underperforming, especially on public goods essential for nature conservation, social development and local livelihoods. The reform has thus not proven able to address its most pressing policy objectives. The forest sector is fragile and badly fit to cope with contemporary conservation and development challenges or restoration of the forest estate. Both political agency and institutional and organisational factors help explain these outcomes. The study provides policy recommendations to Ugandan policymakers for improved forest sector performance.

**S-7 -Can the concept of cultural landscape help scale up restoration?**

**S-7.1**

**Integrating the concept of cultural landscapes into restoration in Europe**

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An ecosystem approach seems to be dominant in ecological restoration. However, to upscale restoration actions it is necessary to consider the landscape scale. In Europe, it is acknowledged that most landscapes were historically shaped by human activities. These cultural landscapes are governed by patterns and feedback mechanisms that should be considered when attempting to implement landscape restoration. Therefore, in order to upscale ecological restoration, it seems important to integrate the concept of cultural landscapes. Ideally, this needs to be supported by research clearly devoted to the subject. After a global review of the literature, we found that the relationship between cultural landscapes and ecological restoration is not very frequent (99 papers), but has shown a recent increase (61 in the current decade). Selected papers were divided into theoretical (45) or practical (54) papers. The majority of papers provided a baseline for future restoration actions (land-use history, people perceptions and traditional practices were the aspects most often assessed); only 10 corresponded to any kind of post-restoration evaluation (people perceptions and ecological aspects were most often assessed). Interestingly, assessment of people perceptions was quite frequent both for providing a baseline or evaluating restoration. By location, we found papers from all continents (total: 32 countries), with Europe being the most representative, with 55 papers distributed among 17 countries, indicating that cultural landscapes are being considered elsewhere but still based where the concept was originated. We conclude that research on the subject is advancing, with a significant trend to the consideration of aspects clearly linked to the sustainability of restoration projects and to broader perspectives which could potentially aid in restoration upscaling. We now have undergoing research aimed at finding out if cultural landscapes are being considered by restoration practitioners in France (unpublished data) and to what extent this consideration can help upscaling.

**S-7.2**

**Restoration in Mediterranean agricultural landscapes for enhancing biodiversity and its services without competition for land**

José M Rey Benayas
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Landscape transformation due to agriculture affects ca. 40% of the planet's land area and is the most important driver of losses of biodiversity and its services (ES) worldwide. There is a range of possibilities within two contrasting types of intervention to enhance biodiversity and ES in farmland, namely "land separation" and "land sharing". Land sharing or wildlife-friendly farming may incorporate "farmland manicure" actions, which involve restoring or creating target elements to benefit wildlife and particular ES without competing for land – e.g. introduction of living fences, woodland islets, ponds and shelter for wildlife. These actions allow wildlife enhancement, provision of a range of ES such as connectivity, pest regulation, maintenance of farmland production, and conservation of values linked to cultural landscapes. In contrast, restoration by land separation, e.g. secondary succession following farmland abandonment and tree planting, would provide all these benefits only at the landscape or regional scales. Strategic revegetation including living fences, road sides, riparian systems and woodland islets are an alternative to designing ecological restoration in extensive agricultural landscapes, and their benefits are well documented in the scientific literature. However, guidance for large-scale restoration of such green infrastructure to provide multi-functional landscapes is often lacking. I provide a practitioner's perspective related to land-sharing restoration actions in central Spain, namely the Fields for Life project with the motto "We produce food and biodiversity". Practical restoration projects are essential if we want to halt biodiversity loss and encourage the return of wildlife in agricultural landscapes. I acknowledge the following funding that supports this body of applied research: projects CGL2014-53308-P from CICYT of Spain, S2013/MAE-2719 REMEDINAL-3 from the Madrid Autonomous Government, and Ministerio de Agricultura, Alimentación y Medio Ambiente (Spain) through the Fundación Internacional para la Restauración de Ecosistemas.

**S-7.3**

**BIODIVERSITY FOR BUSINESS ECOSYSTEM : PROMOTING BIODIVERSITY RESTORATION IN MINING INDUSTRY BASED ON HUMAN VALUES**

Grégory Mahy
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Extractive industry provides good case studies for reconciliation of biodiversity and business ecosystem. Business ecosystem is an economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world. In order to promote reconciliation, business ecosystem needs to articulate the classical way humans take care of nature AND the more innovative thinking on the way nature takes care of human in the business ecosystem. The rooting of this idea may be traced to a strong analogy between natural ecosystems and business ecosystems.
Understanding the perception of ecosystem services by the different actors of the extractive industry help to define biodiversity value for people in this business ecosystem and support action plan for both nature and people. We have explored this dimension in the Life program 'Life in Quarry' with interviews of more than one hundred people at all positions in the companies. What we found is great awareness of the ecosystem services that may be delivered by biodiversity in quarries, with the three categories of ecosystem services cited and a clear focus on cultural services that are directly linked to people and their wellbeing. This means there are great opportunities for improving the wellbeing of extractive business ecosystem and its people by linking biodiversity management to ecosystem services.
Biophilia hypothesizes that contact with nature is deeply rooted in our evolutionary history and contributes to the well-being of humans as individuals. With three examples (a mining fallow restoration, a training program on biodiversity restoration, and a ten year program of endemic conservation) in the tropics, we demonstrate how increasing awareness by training and making people actors of biodiversity strategy may contribute to an increase in biophilia in the extractive industry business ecosystem and how it will help to implement action plan for nature, people and economy.

**S-7.4**

**Restoring biodiversity and ecosystem services in intensive agricultural landscapes**

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Initiatives to restore large areas of degraded land suffer from conflicts with agricultural land use. Farming is seen as essential to provide food and has formed our cultural landscapes, but is also contributing to degradation through impacts on wildlife, flood risk, pollution, greenhouse gas emissions, and soil erosion. Agri-environmental management is promoted as a way to restore biodiversity and ecosystem services while maintaining agricultural production. Positive effects of agri-environment schemes (AES) on wildlife are well researched, but ecosystem service responses are poorly studied. We carried out an experiment over a large farm estate (1,300 ha) in England; splitting it into four blocks, each divided into treated and untreated areas. In each treated area we applied AES

management: wildflower margins, fallow, arable reversion to grass, wildflower addition to grassland, and pond creation. Over three years we deployed state-of-the-art techniques to assess: wildlife using these habitats; pollination and pest control for crops; forage production; sediment and nutrients in water running off fields; water movement in the soil; carbon storage, fluxes of greenhouse gases, and soil microbial health; and how visitors appreciated the different habitats created on the farm. This showed many positive outcomes for ecosystem services. Wildflower margins supported insects which pollinated oilseed rape and decreased aphid attack on wheat, supporting agricultural production. Wildflower addition to grasslands improved forage quality. Ponds improved water quality, but the wildflower margins or fallow land did not capture the pollutants from the run-off water. Grasslands reduced flood risk and stored more carbon and emitted less greenhouse gas than arable land. Wildflower margins and fallow land sequestered carbon. Visitors stated benefits from wildflower margins, meadows and ponds, and to wildlife. This experiment shows that AES can enhance ecosystem services, and provide a mechanism for restoring degraded land while avoiding conflict with agriculture.

**S-7.5**

**What information for restoration and management of coastal social-ecological systems and why?**
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This research assesses social-ecological datasets use in ecological restoration and management of coastal environments. We describe the knowledge of vegetation change with an inventory of existing data on Brittany's cliff-top and coastal wetlands of the Loire estuary (ecological surveys, GIS data, satellite imagery, etc.). We also study stakeholder perceptions and interests to ecosystem and land use changes, and their capacity to use such information to design their current projects and more globally to anticipate environmental changes in land planning. Our results show two different trajectories in cultural landscapes: human activities (leisure, agriculture) tend to decrease in cliff-top system; but tend to increase in the Loire estuary wetlands. We also pointed out a strong network between scientific and stakeholders combined to a considerable ecological database. Paradoxically environmental data is little used by stakeholders: decisions remain mainly empirical for ecosystem restoration or management. We underlined challenges for coastal ecosystem ecological restoration:
- Environmental databases are crucial tools for cultural landscape approaches, especially for the choice of the target ecosystem that cannot be disconnected from long-term system dynamics,
- The importance of geographic databases that allow better knowledge and new ways of monitoring ecosystems. Ten years after the European directive INSPIRE, more and more databases of different stakeholders are accessible and modify the relationship to information and knowledge,
- The development of studies about human use and perception are needed to improve long-term management of restored ecosystems toward the choice of a "desired" ecosystem including human use.
By providing a socio-technical perspective on the use of these data, this research also contributes to a better understanding of the current forms of environmental information governance. Landscape-scale and temporal approach must be developed to improve restoration projects in a changing world.

**O-6- Invasive species**

**O-6.1**

**A global legume invader benefits from extreme weather events under competition**
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Climate extremes and biological invasions threaten ecosystems worldwide. Germination success and seedling emergence in new environments are crucial demographic parameters for invasion and play a key role in the processes of range expansion. We examined the climatic factors affecting germination success of *Lupinus polyphyllus* as well as the single and interactive effects of competition and climate change variables upon its invasiveness to understand the processes driving invasion.
In four experimental studies conducted in Central Europe we assessed 1) germination rate and emergence success of *L. polyphyllus* in greenhouses and climate chambers under climate regimes corresponding to seven eco-regions, 2) stress tolerance against extreme weather events (drought, fluctuating precipitation, late frost) of the invader, 3) competitive effects of *L. polyphyllus* on native temperate grassland species, 4) interactive effects of extreme weather events and competition on invader performance.

*L. polyphyllus* did not germinate in dry (humidity ≤ 50%) and cool (temperature ≤ 5°C) climates, but did in two

moderately cool (12-19°C) and three warm (24-27°C) climates. Drought reduced shoot growth and lead to early senescence of *L. polyphyllus* but did not reduce survival. Under ambient conditions, interspecific competition altered metabolism namely through reduced photosynthetic activity and growth. When subjected to competition plus drought, *L. polyphyllus* conserved water while simultaneously increasing assimilation rate, and consequently showed an increased photosynthetic capacity.
The warm, semi-arid and humid climates are potential invasion areas of *L. polyphyllus.* The invader's resistance to extreme weather events is contrasted by its relatively low competitive ability under ambient conditions. However, the invader seems to benefit from a combination of reduced competition by native plants under drought. Further spread across Europe seems probable as the predicted increase in drought events may favor the non-native legume over native species.

**O-6.2**

**How diversity, density and maturity of restored plant communities influence invasion success**
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Active restoration of native plant cover is increasingly being advocated as a method to reduce invasive alien plant species (IAPS) establishment and spread. Of all the processes underlying invasion resistance, competition for resources is a major process that could be manipulated by restorationists to combat invasion. Tipping the competitive balance in favor of natives could be achieved by giving a time advance to the restored community, generating "priority effects". Through priority effects, the restored native community benefit of a fitness advantage by which they better resist invasions. How priority effects are influenced by community characteristics is still unknown, but could be very useful to practitioners to improve invasion resistance of restored communities. We designed a pot experiment to simulate a situation in which seeds of three IAPS in France (*Ambrosia artemisiifolia, Bothriochloa barbinodis, Cortaderia selloana*) reach soil covered with restored native communities composed of commercial plant varieties. We assessed how species diversity (1, 3 or 9 sp.), density (4 or 15 $g.m^{-2}$), and age of the community (1 or 5 months) influence germination, survival, growth and phenology of the three IAPS. In addition to global community characteristics, we also analyzed how soil nutrient content, community cover, and the features of the immediate neighborhood at the time of introduction (i.e. canopy density and the distance to-/the identity of the closest neighbor) affect the performance of each IAPS individual. This study provides new useful insights to elaborate revegetation strategies effective against IAPS.

**O-6.3**

**Seed and seedling traits have strong impacts on perennial bunchgrass establishment in invaded arid systems**
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Seedling recruitment is an essential step for plant population persistence, and understanding phenotypic traits associated with establishment in disturbed and invaded communities is important for conservation and restoration efforts worldwide. Here, we assessed population-differentiation in potentially adaptive traits of a perennial grass, *Elymus elymoides,* a common component of sagebrush steppe communities in the Western United States. We described variation in abiotic conditions at the collection site and seed and seedling characteristic of 35 populations originating primarily from arid regions of the western Great Basin, and asked how these characteristics predicted field performance. Seeds were planted into five field sites, all near-monocultures of the invasive annual grass *Bromus tectorum*, and all locations experienced similar, below-average precipitation. Phenotypic traits were strongly correlated with field performance across all sites, with remarkably high predictive power: seeds from populations with longer roots, larger seeds, and earlier emergence were significantly more likely to be present at the end of the first growing season ($R^2$ = 0.66, $P$ <0.0001). Abiotic conditions at the collection location were also significant predictors of performance, but models had much lower predictive power ($R^2$ =0.21-0.38). Though the best performers were from similar abiotic conditions as test sites, there were also collections from similar environments that performed poorly, indicating that site abiotic conditions are important first considerations, but not sufficient, characteristics to consider when predicting seedling success in invaded sites. Many factors can lead to the maintenance of variation in wild populations, and a mechanistic understanding of successful strategies in altered environments can be an effective way to find wild population well-suited for restoration in a changing world.

**O-6.4**

**Old lupin sites in Iceland revisited**
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The introduced N-fixing Nootka lupin (*Lupinus nootkatensis*) has for decades been used in land reclamation in Iceland. Around 1990 fifteen lupin sites in southern and northern Iceland were established at its oldest locations. In 2011–2014 the sites were revisited and sampling repeated to get a better insight into its long-term effects on plant communities. Analysis of vegetation data was carried out with multivariate ordination. In the ordination lupin age and density correlated strongest with plots distribution. With increasing age of lupin, plant species richness declined as well as cover of dwarf shrubs and bare ground, while grasses, forbs and horsetails increased their abundance. The ordination revealed three main trajectories in succession at old lupin sites: a) towards a lush, relatively species-poor, lupin-grassland, developing furthest at southern sites with ample precipitation; b) towards a lush, species-poor, lupin-horsetail community on relatively rich soils, mainly at drier northern sites; c) towards a species-rich heathland at dry, barren, inland northern sites. One site was invaded by the exotic nitrophilous Cow Parsley (*Anthriscus sylvestris*) which totally replaced the lupin and formed monospecific patches. At most sites the lupin gained maximum cover in 10–15 years after which it declined. At a few southern sites, where the precipitation is highest, the lupin fully degenerated within 25–45 years. We postulate that a development of dense moss and grass layer underneath the lupin prevented its regeneration from seeds. With aging and gradual dieback of the original colonizing plants the lupin disappeared. In Iceland spread of lupin is mainly held back by sheep grazing. With declining sheep farming and climatic warming the lupin will further invade extensive, barren areas and heathlands with large effects on flora and fauna. It will also facilitate further colonization of other invasive species, such as the Cow Parsley.

**O-6.5**

**Long-term effect of climate on the restoration success of Pannonian sand grassland**
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Long-term changes of the environment – especially drought events – can influence vegetation development that can modify the results of restoration trials. We studied the combined effect of climate and management on restoration success on the long-term. The objective of the restoration was to assist the recovery of Pannonian sand grassland of clear-cut non-indigenous black locust (*Robinia pseudo-acacia*) forest plantation. Three stands were selected in the sand dune area of Kiskunság, Hungary. The stands were clear-cut in the winter of 1994-1995 followed by chemical (GARLON 4E) application on tree trunks. Mowing was applied as management to assist grassland recovery in six 10m by 10 m parcels and its success was compared to unmown control and semi-natural reference. Mowing was applied twice a year between 1995 and 2001. Vegetation was sampled in June and August yearly in 1995-1999 and re-sampled six times until 2017. We characterized the climate of the region based on the drought index PAI and used multiple regression to calculate correlation between vegetation and PAI. Mowing assisted the recovery of grassland vegetation, whereas in the lack of mowing, a dense shrub cover developed mainly of hawthorn (*Crataegus monogyna*). Mown plots were more sensitive to drought than control plots in general. However, the expansion of neophytes common in the region threatens the outcome of restoration of Pannonian dry grasslands.

**O-6.6**

**Can herbicides be used control the spread of Cow Parsley (Anthriscus sylvaticus) in Iceland?**
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Cow Parsley (*Anthriscus sylvaticus*) is an exotic species which has spread widely in Iceland. It is prone to invade disturbed, nutrient rich habitats that have limited grazing pressure, such as roadsides, abandoned hayfields and old Nootka lupin (*Lupinus nootkatensis*) patches. Cow Parsley is a tall herb and reproduces both from seeds and from root buds. In 2007 the municipality Eyjafjardarsveit in N-Iceland started a research project on how to control the distribution of Cow Parsley using herbicide (glyphosate). Specific aims of the study were to; a) map its distribution on roadsides within Eyjafjordur, and to find out b) if repeated use of herbicide (3-4x) would permanently decrease its cover, c) which dates of applying the herbicide would give the best results and d) if a stronger mixture of the herbicide would give better results. Out results showed that during a 6-year period, the distribution of Cow Parsley patches at roadsides had increased on average by 62% in the whole area, but least within the municipality Eyjafjardarsveit (19%), where active measures had been taken to eradicate it. Repeated application of herbicide did only temporarily decrease the cover of Cow Parsley and this method is therefore not suitable for permanently eradicating the species from a certain area. The spraying gave the best temporary results if applied at the end of May or beginning of June. A stronger mixture of the herbicide gave better results, but also those effects were only short term. Decisions on if and how to control invasive alien species with an herbicide, always must consider the harm from the invasive species relative to the potential harm that can possibly arise from using a herbicide. The authors recommend using mixed methods, like grazing, cutting and perhaps seeding of other plant species, when trying to decrease the cover of Cow Parsley.

## O-7- Grassland/heathland restoration

### O-7.1

**Turf-lifting, seed sowing, natural regeneration - a cost-benefit analysis of techniques for calcareous grassland restoration.**

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This study, now in its sixth year, compares three approaches – turf lifting and reinstatement, seed sowing, and natural regeneration – to the restoration of calcareous grassland destroyed by the construction of a water pipeline at Crane Down in the South Downs National Park, England.
Lowland calcareous grassland is one of the most diverse habitats in western Europe, but is subject to multiple threats including agricultural intensification, undergrazing and destruction for housing and infrastructure. In the UK, the development of linear infrastructure – roads, railways, pipelines, buried cabling etc. – poses a significant threat to calcareous grassland and other priority habitats, and has become a focus of restoration practice.
The work at Crane Down provides an opportunity to compare the effectiveness of the three approaches in restoring the pre-disturbance plant community and relate this to the cost and practicability of implementing different techniques at different sites and scales. Turf lifting and reinstatement was found to be an effective but expensive technique suitable for high priority areas, although the relative benefits appear to be reducing over time. Seed sowing and natural regeneration produced very similar results, suggesting the additional cost of seed may not be justified in narrow linear developments with good opportunities for natural seed dispersal.
Recent data is presented and discussed, with an overview of the specialist techniques developed for turf lifting, storage and reinstatement, and bulk seed harvesting in calcareous grassland.

### O-7.2

**Topsoil removal in grassland restoration: Is there a negative long-term legacy on soil nematode communities?**

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Successful restoration of semi-natural grasslands on previously intensively used farmland needs to overcome manifold barriers such as high soil fertility due to excessive use of fertilizer and manure, missing propagules of the targeted above- and belowground flora and fauna, and the dominance of degraded or disturbed plant and animal communities. A combination of removing the topsoil and introducing propagules of the target plant species has become one of the major tools for nature conservation agencies and practitioners in many central and northwestern European countries to restore former species-rich grasslands. However, in Switzerland, its implementation has provoked an ongoing dispute between supporting nature conservation and rejecting soil protection agencies since topsoil removal favors species-rich plant communities, however on a short-term it strongly affects soil communities and soil properties. Currently, there is a lack of long-term data on the development and recovery of restored species-rich grassland ecosystems after topsoil removal. Here we use two well-established bioindicators, plants and soil nematodes, and assess their community composition and structure to quantify restoration success after 22 years since the start of restoration. As expected, nematode community composition indicated reduced nutrient availability. Interestingly, nematode composition and structure also revealed successful recovery from perturbation caused by restoration methods. Plant communities sustainably profited from the reduction of soil nutrients as indicated by higher species richness and diversity. Our results show that topsoil removal does not have a negative long-term effect on soil nematode community composition and structure, while at the same time achieving a successful restoration of the targeted species-rich grasslands.

### O-7.3

**Successful restoration of abandoned, dry sandy grasslands and heathlands by year-round cattle and horse grazing**

Katrin Henning, Antje Lorenz, Sabine Tischew
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The spread of competitive grasses as well as changes in species composition and vegetation structure are direct consequences of grassland and heathland abandonment. As an alternative to more costly management measures, year-round low-intensity grazing with large herbivores is increasingly used to restore and maintain semi-open habitats. However, the suitability of this grazing regime has not yet been investigated for long-abandoned, highly degraded but nutrient-poor sandy grasslands and heathlands. It is still unclear if year-round grazing is suitable for preventing the further spread of highly competitive grasses such as *Calamagrostis epigejos* while simultaneously maintaining or improving characteristic bird and plant species as well as vegetation structure.

Hence, since 2008 we studied the impacts of year-round low-intensity cattle and horse grazing on the development of *Calamagrostis,* the vegetation structure, plant species richness and the frequency of birds of long-abandoned but nutrient-poor dry sandy grasslands and heathlands, their mosaics and *Calamagrostis* stands within an 800 ha heathland.
Grazing successfully reduced the coverage of *Calamagrostis*, whereby *Calamagrostis* stands developed towards species-rich sandy grasslands. The quality of the vegetation structure was improved by enhancing the proportion of bare soil, while litter and grass cover as well as the coverage of ruderal indicators were significantly reduced on grazed sites in comparison to ungrazed sites. Moreover, we found an overall positive grazing effect on plant species richness: Total species number, number of target as well as of subordinated target species significantly increased within the vegetation types. In addition, the number of typical bird species increased by grazing: Nightjars increased sevenfold (from 15 to 103 breeding pairs), woodlarks have tripled (from 32 to 93 breeding pairs), and the hoopoe has re-established.
Thus, we conclude that year-round low-intensity cattle and horse grazing is a suitable management tool for restoring, maintaining and even improving long-abandoned, nutrient-poor sandy grasslands and heathlands.

**O-7.4**

**'Seeds of change' for grassland restoration produced by agricultural technology: Rhinanthus alectorolophus multiplication and effects**
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The possibility to utilize root hemiparasites from genus *Rhinanthus* (Orobanchaceae) for grassland restoration has already been published by researchers from Netherlands in the 1970s. Practical large-scale restoration with the seeds of *Rhinanthus minor* was tested 30 years later in England and Belgium, but so called 'seeds of change' did not meet expectations and whole technology was almost forgotten. In 2012, our research group discovered that other species *Rhinanthus alectorolophus* (former weed of cereals, native to Central Europe) is substantially better for suppression of expansive grasses such as *Calamagrostis epigejos* and *Brachypodium pinnatum*. Thus, we conducted a pilot experiment testing the suitability of commonly cultivated plants as host species and this detected *Festuca arundinacea* and *Lolium perenne* to be the most adequate for *R. alectorolophus* seed multiplication. During last five years close cooperation of biologists and agronomists helped to elaborate agricultural technology, which enables to produce 200 – 400 kg seeds per one hectare of arable land. Production based on standard agricultural and seed cleaning machinery ensures that 1 kg of seeds is currently sold for 8 EUR (almost 100times less than in Western Europe). Hence, grassland restoration using 15 kg of *Rhinanthus* seeds per hectare has become reasonable alternative for nature conservation purposes also from the short term economic perspective.
Several field experiments investigating the effect of *R. alectorolophus* on plant species composition, vegetation structure and grass : forb ratio confirmed us that this species is able to transform species poor grassy road verges as well as degraded dry, mesic or wet meadow communities into species rich stands within 2 – 3 years and support the abundance of pollinators. In comparison to increased mowing frequency, standard technique used by nature conservation to suppress vigorous clonal grasses, application of *Rhinanthus* has no detrimental effect on the occurrence of endangered plant species.

**O-7.5**

**Large-scale application of diaspore transfer with plant material in restoration - revisited after 14 years**
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Species-rich floodplain meadows are valuable, but severely threatened ecosystems and have therefore been in the focus of restoration projects across Europe. The re-establishment of endangered plant species is limited by rare or missing source populations, low dispersal abilities and low recruitment rates due to unfavorable abiotic and biotic site conditions. In restoration projects, different methods to overcome these limitations are applied, including sowing of seed material, sward transfer or diaspore transfer with seed-containing plant material. These methods have proven successful to initiate a development towards communities of high nature conservation value. However, the long-term success of grassland restoration has rarely been studied.
We assessed the long-term development of floodplain meadow communities that were restored via application of diaspore-containing plant material without topsoil removal on former arable land and former species-poor grassland. In a previous study four years after restoration, we found that 92 species were successfully re-established, with higher re-establishment rates on former arable land than on former grassland. The greatest obstacle for success was competition by co-occurring vegetation, while simultaneous sowing of grasses and topsoil disturbance had only small effects. Fourteen years after restoration, the proportion of target species in the community and overall species composition still differs between former arable land and former grassland, but to a much smaller extent than in the first years. Species richness and the proportion of plant material species increased, while arable weeds and resident

grassland species' proportions continuously declined. Other restoration projects that seemed successful in early years after restoration failed in the long term. In contrast, the restoration projects presented here proved to be still within the target range fourteen years after the restoration took place. Even former species-poor grassland where the initial re-establishment of target species was impeded by competition of resident species showed high proportions of target species.

**O-7.6**

**Development of a terrestrial orchid species under year-round horse grazing - a 9 year experiment**
Martina Köhler[1], Sabine Tischew[2]
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Horse grazing as a management tool for orchid-rich calcareous grasslands is rather uncommon. On the one hand, conservationists fear an uneven use of the pasture with partial abandonment, encroachment or reduced ground light conditions, as well as partial over-grazing with negative effects as latrines, grazing lawns, or impairing of typical plant species. Concerning orchid species conservationists often fear even the total loss of populations. On the other hand, large herbivore grazing is an economically profitable management tool for stopping abandonment of valuable habitats. From 2009 - 2018, we studied the frequency of the orchid species Ophrys apifera, and horse activity (Koniks) on 455 0.25 ha plots within a 87 ha year-round pasture. On 14 1 m² plots population dynamics and external impact on leaves of O. apifera were studied 4 times per year from 2009 - 2018. Our results showed a strong variance of abundance of the studied species between central and marginal sites of the pasture, also related to horse frequency. The max. amount of reproducing individuals counted on the 455 plots was 3,174 in 2014. The mean number of emergent plants on the 1 m² plots was 77.8 (± 19.8), flowering plants accounted for 11 % (± 12.2). Dormancy was recorded at 12 plants with a dormancy period of 1 year for 75 %. Frost, and in 2 years, trampling had the highest external impact on the leaves. Herbivory through horses had only little impact. We conclude that low-intensive horse grazing is suitable to restore +/- plain and large-scale orchid-rich calcareous grasslands.

**S-8 - Promise & perils of peatland restoration in the climate change era**

**S-8.1**

**Embracing pragmatism, rejecting 'novelty': applying the SER International Standards to peatlands on the rehabilitation-restoration spectrum**
Paddy Woodworth
Missouri Botanical Gardens, DUBLIN, Ireland

Ecologically intact peatlands are usually vast, and efficient, carbon sinks. Degraded peatlands generally emit CO2. These considerations have, in a number of countries, triggered the release of significant funds into peatland restoration as a means of mitigating climate change. For those espousing ecological restoration as a cutting-edge conservation strategy, this development is a very welcome challenge, but also carries dangers. Restoration, as defined in the SER Primer -- and recently refined in the new SER International Standards -- aims at the holistic recovery of degraded systems to their pre-disturbance historical trajectories, based on reference models derived from un-degraded local native ecosystems. If the speed of carbon sequestration is the sole criterion for restoring peatlands, however, opportunities to restore the other functions and processes of these systems, and their attendant rich biodiversity, may be lost. 'Novel ecosystem' advocates argue that this doesn't matter, or that the SER restoration targets are anachronistic, that there is no ecological baseline any more, that 'degradation is in the eye of the beholder' (Hobbs, *Restoration Ecology*, March 2016). These views are a gift to governments and corporations who have no concern with authentic restoration aspirations, and seek the cheapest and quickest tick on the climate mitigation box, often through inappropriate afforestation of peatlands. However, experience in Ireland shows that even quite simple procedures – blocking drains – can lead to the recovery of climate-positive peat generating processes, and the return of much local biodiversity. Ecological restoration is always case-specific, and never creates a carbon copy of the reference trajectory. And we must be pragmatic, sometimes, circumstances may dictate that full restoration is not the best option. I will argue that the SER Standards offer an essential yardstick to evaluate useful and legitimate environmental repair projects in peatlands, on a spectrum from rehabilitation to ecological restoration.

**S-8.2**

**Monitoring of peatland restoration success: methodology and techniques**
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The definition of ecological restoration and criteria of its success is difficult to apply directly for the assessment of peatlands restoration success. Ecological restoration according SER is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. The peatland ecosystems in temperate zones developed during 5-10 thousand years, and in tropics twice as long. Can we consider the recovery of initial ecosystem as a target in a scale which is assessable by means of monitoring?
The project “Restoring Peatlands in Russia – for fire prevention and climate change mitigation” (PeatRus) is implemented by Wetlands International with partners since 2011 and is considered as an example of success. The project was awarded the UNFCCC Momentum for Change Award in 2017. The planning of restoration was designed with reference to the needs of reducing peat fires, mitigation of climate change by reduction of GHG emissions, maintaining of biodiversity and livelihoods, enhancing of ecosystem services availability to local stakeholders and economic benefits. In the many cases the listed targets are contradicting each other. How to assess the effectiveness in this case?
To make the outcomes assessable we followed the principle to evaluate each component with the most neutral and scientific sound available method. One has to agree that restoration targets have different time frames and different stakeholders involved. Many of the criteria could have only prognosed values.
The presentation addresses the monitoring methods of the parameters of peatlands under restoration. The results of this monitoring are the basis of the integrated methodology for the restoration success assessment, with relation to global level (climate and biodiversity), regional level (economic and natural resources) and local level (social and economic processes). The methodology opens possibilities to integrate outcomes of the evaluation on the different scales and time frames.

**S-8.3**

**Forest to bog restoration: past lessons and future direction**
Roxane Andersen[1], Paul Gaffney[2], Wouter Konings[2], Ainoa Fernandez-Pravia[2], Renee Hermans[2], Jens-Arne Subke[2], Angela Creevy[2], Richard Payne[2], Neil Cowie[2], Mark Hancock[2], Daniela Klein[2], Myroslava Khomik[2], Rebekka Artz[2]
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Between the 1960s and the 1980s, tax incentive schemes led to large scale afforestation of blanket bog across Europe. The Flow Country, the largest blanket bog in Europe found in the north of Scotland, was particularly affected: over 60,000 ha were drained and planted with non-native conifers, fragmenting an otherwise open landscape. Following pressure by conservationists, afforestation was halted, and in the late 1990s the first attempts of forest-to-bog restoration started with felling and drain blocking.
Today, peatland restoration and its associated carbon benefits are being portrayed as one of Scotland’s best asset to fight climate change. As a consequence, there are increased subsidies for peatland restoration, which has led to development of new machinery and techniques. Forest-to-bog restoration has entered a new phase: early trials are being re-visited for further management, and new sites are being restored with entirely different approaches.
In recent years, a large number of projects have documented how early restoration trial involving felling and drain blocking have progressed towards blanket bog in terms of water quality, nutrient cycling, carbon sequestration, and biodiversity. This talk will present evidence that, even after twenty years, the legacy of the forestry was still preventing the recovery of many ecosystem processes and stopping key species across a range of taxa from coming back. Continued monitoring and collaborative work will be needed to determine whether ongoing management and new approaches are enough to overcome this legacy and bring back functioning blanket bog – but also what to do when restoration is no longer an option.

**S-8.4**

**Rewetting of eutrophic cutover bogs: harming a climate-friendly carbon balance?**
Svenja Agethen, Klaus-Holger Knorr
University of Münster, MÜNSTER, Germany

Worldwide proceeding drainage of peatlands for land-use and industrial peat extraction increases oxic respiration of carbon stored in these peatlands and thus, drained peatlands release enormous amounts of $CO_2$ to the atmosphere. To stop carbon losses from cutover bogs, the most important restoration measure is rewetting. However, most bogs in Central Europe have been under agricultural use prior to peat harvest and/or are subject to high atmospheric N deposition. After rewetting, elevated nutrient concentrations often lead to graminoid-dominated vegetation (e.g. by *Juncus effusus*). In comparison to peat mosses, graminoids provide rather labile organic matter for decomposition. For below-ground carbon processing, external nutrient supply from pore waters, internal nutrient supply from plant litter, and the labile organic matter of the recent vegetation has been assumed to increase mineralization of stable organic matter from peat (‘priming effect’) and to fuel $CH_4$ production. Additionally, vascular plants in waterlogged environments have been reported to increase $CH_4$ emissions by venting of $CH_4$ through aerenchyma. Our experiments conducted in North-West-German restoration sites put these concerns into a more optimistic perspective: In an incubation experiment, we showed that under waterlogging, neither nutrients in the pore water, nor nutrients bound in organic matter, nor labile organic matter from graminoid litter led to priming effects.

Furthermore, ex situ mesocosm- and field experiments repeatedly showed an oxidation of the rhizosphere of common graminoids in rewetted cutover bogs. Thus, concentrations of CH4 in the peat were reduced by methanotrophy or even thermodynamic suppression of methanogenesis. Flux measurements suggested that *Juncus effusus* mono-stands on cutover bogs have a neutral to even slightly negative warming potential. Overall, graminoid dominated, rewetted bogs might provide a suitable intermediate stage that reduces nutrient availability and thereby supports the re-establishment of peat mosses and effective carbon sequestration on the long-term.

**S-8.5**

**Finding common ground for people, planet and profit: stories from Ireland**
Catherine Farrell
Bord na Mona, TULLAMORE, Ireland

Peatlands are integral to the Irish landscape, accounting for an original cover of up to 17% of the total land area of the island, prior to a period of extensive modification in the last centuries. As well as being a significant part of the landscape, peatlands have also played a prominent role in the social and economic development of the country, and are therefore strongly linked with the Irish culture. Since the 1970s, the approach to peatlands has shifted from one of 'let's modify' to 'let's conserve', with an increasingly widespread view in the 2000s of 'let's restore'. Nowhere is this more apparent than within the operations of the Irish Turf Company, Bord na Móna. In the last twenty years the company has invested in a range of rehabilitation and restoration measures across its 80,000 hectare peatland estate. While the main approach has been to stop further degradation (cease cutting and drainage) and take positive measures to reverse those degrading effects (drain blocking, landscaping), working with the communities living on the edges of the bog areas has also been a key feature in the success of the work to date. Case studies of peatland rehabilitation and restoration projects will be presented to illustrate: (i) the challenges of practical peatland work, (ii) the overall positive outcomes of basic rehabilitation and restoration measures and (iii) the range of involvement and interest taken by communities.

**O-8 -Restoration & tourism**

**O-8.1**

**Ecological restoration information among the tourism infrastructure: the diversity in time and space**
Adam Snopek
University of Warsaw, WARSAW, Poland

Many issues concerning ecological restoration are an important element of the content of information boards on tourist and educational trails. The content of the boards may present the discussed issues in various ways, depending on the location as well as on the founder specifics. The content adequacy of the boards may also differ in terms of the current knowledge. A review of the cases regarding to woodland restoration, grassland restoration, rare species restoration and post-mining reclamation reveals some trends in environmental education and in the restoration itself, as well as the diversity of the founders' views based on their current intentions and some controversies related to them.

**O-8.2**

**RESTAURATION OF DANUBE TOURISM AREA THROUGH SUSTAINABLE MOBILITY**
Lucia ILIEVA
CSDCS, SOFIA, Bulgaria

The Danube region is one of the most promising tourism destinations in Europe but most of the trips along the riverside are carried out by car. The quality of public transport as well as the coordination with other mobility services is still weak especially in the lower sections of the river. Integrated multimodal transport services and information systems are missing. Existing transnational tourism information platforms (e.g. Danube.travel) are mainly focusing on the description of touristic attractions and not how to reach them in a sustainable way. The dominance of car usage causes a lot of environmental problems: air pollution, noise, congestions and accidents that decrease the attractiveness of the destinations. The Danube wetlands, parks, forests, picturesque canyons and the river itself need urgent restoration.
Ten Danube countries started working on a project "Transdanube.Pearls"(funded by the DTP) which aims to develop sustainable mobility and tourism services along Danube thus restoring its unique natural assets. A notion of "Danube pearl" is introduced meaning a site with environmental friendly offers for tourists. For achieving sustainable mobility, appropriate transport services along the whole travel chain are needed. By better combining public transport with flexible transport services, cycling and walking, the project will improve intermodal travel chains and thus increasing the quality and resilience of the whole region.
In order to bring forward the concept of sustainable mobility in tourism, cooperation between different sectors and different levels of governance is paramount. The project will set up a network of destinations committed to

sustainable mobility involving stakeholders from the tourism and the transport sector in each Danube country. Mobility information centers will act as one-stop-shops for provision of integrated tourism and mobility information to visitors. The network will increase the visibility of the Danube destinations committed to sustainable mobility at the world tourism market.

**O-8.3**

**ASCENT - Apply Skills and Serve our Environment with New Tools**

David Arnar Stefansson
SCSI, REYKJAVIK, Iceland

The ASCENT project will bring together Local and Environmental Authorities to collectively address the environmental challenges facing the conservation and enhancement of Areas of Natural beauty in the partner regions: Iceland - Geosite Eldhraun (e. Laki lava field) (Skaftáhreppur) Úlfarsfell Mountain (Reykjavík and Mosfellsbaer municipalities); Slieve Donard (Eastern Mourne Mountains), Slieve Gullion and Ring Dyke (Northern Ireland); Mount Errigail, Derryveagh Mountain, (Donegal Ireland); Hossa region (Finland) and The Hardanger Mountain Plateau (Norway). Due to unregulated access to sites and natural erosion these regions are experiencing degradation, loss of unique bio-diversity and bio-resources. The ASCENT project will develop management plans across the programme area to assist Local Authorities and other stakeholders to monitor these sites and implement innovative measures to ensure their economic and environmental sustainability.The project will look at how to use and manage the mountains and upland areas responsibly, will examine new ways to deal with the sites, learn from other regions using a teacher:learner principle, examine habitat damage and habitat restoration, and introduce appropriate site specific mitigation measures. The project will create living laboratory situations whereby management techniques can be implemented and skills gained locally on learning from other regions. It will seek to explore new concepts for balancing tourism, cultural and economic interests with environmental needs. The project will disseminate and generate knowledge on the impacts on the environment, local biodiversity resources and promote civic pride among communities of their environmental resources, and unique local cultural heritage. Project outputs include learning, exchange of ideas and measures to arrest the decline and degradation of Natura 2000 sites and other sites (SACs) caused by unregulated / unrestricted access to mountains.

**O-9-Restoration in arctic and alpine areas**

**O-9.1**

**Spatio-temporal patterns of crowberry (Empetrum nigrum ssp. hermaphroditum) colonisation at an alpine spoil heap**

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Natural revegetation plays a distinct role in ecosystem restoration, as it ensures the emerging vegetation's adaptation to the local environment. In alpine areas, dwarf shrubs such as crowberry (*Empetrum nigrum* ssp. *hermaphroditum*) are keystone species with considerable influence on other biota. Although crowberry suppresses establishment of other species in favourable conditions, it might act as a nurse plant in the harsh alpine environment. Crowberry's spatial and temporal colonisation patterns may therefore have important implications for natural revegetation and restoration success in alpine areas.
We studied emerging crowberry population at a 32 years old (in 2016) alpine spoil heap in western Norway. Limited clonal propagation enabled identification of single individuals originating from naturally dispersed seeds. In autumn 2015, we measured and collected 90 individuals for age determination and development of an allometric (age ~ size) model. In early summer 2016, we precisely mapped and measured more than 2200 individuals in three parallel transects at increasing distances from spoil heaps' northern edge bordering towards undisturbed surroundings and continuous crowberry scrub. Minimum age of the mapped individuals was estimated by the allometric model. Preliminary analyses suggest effects of distance to the northern edge on overall crowberry density in the transects, and distance to the closest spoil heap edge influencing local variations in the density. Point pattern analyses suggest significant clustering at distances < 2m, and possible association of crowberry clusters with local surface patterns (i.e. rills and swells).
The final results for analyses of point patterns and age structure will be discussed with implications for restoration in alpine areas, and design of restoration sites.

**O-9.2**

**Revegetation of disturbance due to tracked vehicles on Spitsbergen, Svalbard, 78 N**

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Recovery of High Arctic soils and vegetation from disturbance is slow, and it may take decades or even centuries for the original vegetation composition and cover to be restored. This study compared suitable methods to assist revegetation of tracks formed by a caterpillar-tracked vehicle driving on unfrozen tundra on Svalbard. Six different treatments were applied in the field and measured over two seasons; fertilizing, covering the ground with fibre cloths, fertilizing in combination with fibre cloths, seed sowing with local species, adding plant cuttings of local species and tilling of the soil. The largest increase in vegetation cover over the two seasons was found for the two treatments containing fertilizer. However, seedlings from the seed sowing treatment had high survival in season two, which suggests that a natural species composition may be increased in the disturbed site if survival continues. The combination of fertilizing and seed sowing with local seeds may thus be a successful method to assist revegetation in the High Arctic.

**O-9.3**

**Re-establishing reindeer grazing habitat on alpine mining sites; from case studies to full-scale restoration**
Åsa Granberg, Tove Hägglund
Enetjärn Natur AB, UMEÅ, Sweden

Restoration focused on the establishment of natural alpine heath vegetation on former mining sites is a tool to re-establish summer grazing grounds for the Sami reindeer herding community. However, alpine ecosystems are known to be among the most vulnerable to climate change, potentially decreasing the distribution of grazing grounds by speeding up establishment of new vegetation – predominantly *Salix* species and ericaceous shrubs. Here we present a study initiated by the mining company Boliden to investigate potential methods to enhance the establishment of alpine heath vegetation on the former Stekenjokk mining area. The study started in 2013 with small-scale trials and during the following years the trials were evaluated and gradually enlarged. We focus this presentation on preliminary results and lessons learned from this case study – both from a methodological perspective and in the light of climate change which can affect the outcome of such restoration efforts.

**S-9 -Getting under & ahead of climate change; Soil resilience & assisted migration**

**S-9.1**

**Using soil amendments to restore above- and belowground productivity on abandoned mine sites**
Deborah Page-Dumroese, Kasten Dumroese, James Archuleta, Joanne Tirocke
USDA Forest Service, MOSCOW, ID, United States of America

Above- and below-ground components of ecosystems are linked through a variety of interactions. However, restoration efforts sometimes ignore these linkages and target either soil processes or plants species. Restoration efforts may be hampered by poor soil physical or chemical properties or reduced soil microbial communities which may result in failure of planted or seeded species to thrive. To enhance degraded ecosystems, soil amendments may be necessary to promote increased soil organic matter, water holding capacity, and nutrient cycling. To facilitate abandoned mine land restoration, biochar, biosolids, and wood chips were used to build soil as single amendments or in combination. These soil building treatments were then planted with two grass species (*Bromus carinatus* Hook & Am. and *Elymus glaucus* Buckl.) on one-half of the treatment plots and were seeded with a native plant mix on the other half. After two years, soil cover on the seeded side and overall plant survival was highest in the biosolid + wood chip and biosolids + wood chip + biochar treatments. In general, *Bromus carinatus* had better survival after two years than *Elymus glaucus*. Improved *Bromus* survival may be associated with the nutrient and water needs of this species. The added stresses of climate change underscore the need to improve soil conditions when restoring vegetation. Changes in soil properties from soil amendments meant to improve critical soil functions will change how plant species respond and highlights the need to match seedlings with site conditions to ensure adequate plant cover.

**S-9.2**

**Matching restoration plant materials to soil conditions using the Target Plant Concept**
Jeremiah Pinto, Dian Haase
USDA Forest Service, MOSCOW, United States of America

In restoration, afforestation, and reforestation projects, outplanting environments pose a myriad of challenges to establishing seedlings. These environments often yield conditions beyond those deemed acceptable for natural reestablishment. Yet these challenges can only be realized after a thorough site evaluation that includes spatial and temporal factors. Only then can the primary limitations to establishment be understood and consequently overcome. A model of seedling establishment outlines how seedlings engage their surroundings and begin to survive and grow on a site. This model characterizes the physiologic, atmospheric, and edaphic process that factor into a target

seedling's design. Of these three processes, edaphic conditions play one of the primary and critical connections a seedling has to its new environment, but it is often not comprehensively evaluated. Soil characteristics such as seasonal moisture patterns, temperature, nutrients, depth, texture, chemistry, and biota all influence the rhizosphere of a seedling's newly egressed roots and should be part of the discussion in target seedling design. Furthermore, different site preparation tactics can mitigate site limiting factors and aid seedling establishment. In this presentation, the Target Plant Concept will be highlighted as it pertains to the interaction of these factors and will be discussed and supported using research and case study information.

**S-9.3**

**Outplanting Seedlings Grown with Biochar to Restore Forests and Sequester Carbon**
Kasten Dumroese
US Forest Service, MOSCOW, United States of America

A variety of recent international "challenges" toward restoring degraded forests will require active restoration, and in particularly, the outplanting of high-quality, nursery-grown seedlings. Biochar, the by-product of converting woody biomass to energy, can be used to amend the substrates used to grow seedlings in container nurseries and offers opportunity to sequester carbon as part of the normal outplanting process. In addition, employing more sustainable organic materials, such as biochar, as growing media to produce reforestation seedlings is gaining interest because they are perceived as a way to avoid issues (e.g., reduced biodiversity, increased carbon emissions) associated with traditional Sphagnum peat moss harvesting. Recent estimates suggest that the number of seedlings needed to help achieve the ever-growing list of national and multi-national programs could easily exceed 200 billion ($200 \times 10^9$). Although some maintain that passive restoration leads to restoration of more diverse forests, impacts from invasive species (insects and diseases) continue to degrade natural forests, and contemporary changes in climate are predicted to exceed the ability of trees to move across the landscape or adapt from an evolutionary perspective. Thus, maintaining species and their populations on the landscape to ensure the valuable functions of diverse, currently occurring or future novel forests may require more innovative approaches, such as assisted migration, which may be most easily accomplished through outplanting.

**O-10-Costal/marine restoration**

**O-10.1**

**Stakeholder perceptions on marine restoration: policy targets and supporting actions**
Nadia Papadopoulou[1], Christopher J Smith[2], Rolf Groeneveld[2], Katerina Sevastou[2], Stephen Hynes[2], Wenting Chen[2], Kristen Ounanian[2], James Aronson[2]
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In recognition of the many degraded ecosystems and the need to prevent further habitat degradation and halt biodiversity loss, many International and European policies have put conservation and restoration at the top of their environmental agenda. Reducing pressures, minimizing damages, putting areas aside for conservation and implementing rehabilitation and restoration actions are all part of the toolkit available to Governments and the global society to support achievement of many high-level policy objectives.
Benefits of terrestrial ecosystem restoration are being showcased by many successful large-scale projects and the practice is being embraced by hundreds of thousands of people across the world. Coastal ecosystems have been extensively used and impacted by multiple human activities over time but restoration as a concept and practice is lagging behind for many strictly marine ecosystems. Beyond the many scientific, technological, socioeconomic and feasibility gaps and challenges, little is also known about the social acceptance of marine restoration. Within the MERCES project, the first European H2020 project to focus on restoration concerning a number of key marine ecosystems including the deep sea, we investigate stakeholder perceptions about restoration of degraded marine ecosystems (that we don't even usually get to see). We are looking at reasons behind acceptance of conservation and restoration, degrees of agreement for major policy targets, points of difference and modes of support for restorative actions. A Greek national, a European and an International survey were conducted (the latter one linked to SER media resources/audience) by means of an anonymous on-line questionnaire. Stakeholders include local and central government, NGOs and MPA managers, researchers and marine users. Results from the surveys indicate that stakeholders in general agree that marine restoration can reverse negative human impacts but there is some heterogeneity in their degree of agreement and preferences towards specific targets and restorative approaches.

**O-10.2**

**Restoring macroalgal Cystoseira forests: life-history traits highlight the need for combine active and passive restoration**
Alba Medrano, Cristina Linares, Pol Capdevila, Ignasi Montero-Serra, Marta Pagès, Graciel·la Rovira, Bernat Hereu
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The habitat-forming *Cystoseira* (fucoids) species dominate algal forests communities in the well-preserved Mediterranean coast. Over last decades, many of these communities have been degraded due to several stressors such as fishing nets, pollution or sea-urchin overgrazing as consequence of the overfishing, transforming *Cystoseira* forests in simplified communities. Face to the loss of these highly diverse forests, there is an increasing need to combine passive and active restoration techniques to ensure their preservation.
The present study is carried out at Medes Islands Marine Reserve and surrounding areas (NW Mediterranean), where two emblematic *Cystoseira* species (*C. elegans* and *C. zosteroides*) display different conservation status. Because of their different life history traits, they are two model species in which to apply different restoration actions. *C. zosteroides* is a deep water long-lived species, which shows slow natural recovery rates and is threatened mostly by local stressors. Conversely, *C. elegans* is a dynamic seasonal growing species inhabiting shallow waters, which in recent years spread from the marine reserve to non-protected areas, except in areas dominated by sea urchins barrens. These contrasting responses provide the opportunity to restore coastal hard-shallow degraded habitats using different restoration tools.
According to the ecology of both species, several restoration techniques to preserve *Cystoseira* forests were evaluated. For *C. zosteroides*, adult, juvenile stands, and fertile apexes were transplanted from natural and well-preserved populations to new potentially locations at the same depth range (25m depth). We estimated the viability of restored populations and the success of the different techniques tested quantifying the mortality, growth and recruitment rates as well as their physiological condition. The same techniques were tested for *C. elegans* at 5m depth inside and outside the marine reserve, but also including the eradication of sea-urchin populations.

**O-10.3**

**MERCES: Marine Ecosystem Restoration In Changing European Seas (H2020 Project)**

Cristina Gambi[1], Roberto Danovaro[2], Nadia Papadopoulou[3], Anthony Grehan[4], Christoffer Boström[5], Johan Van de Koppel[6], Joaquim Garrabou[7], Simonetta Fraschetti[8], Telmo Morato[9], Andrew K. Sweetman[10], Chris McOwen[11], Trine Bekkby[12], Jan P.M. Van Tatenhove[13], Ronan Long[14], Stephen Hynes[4], Wenting Chen[12], David Billett[15], Eva Ramirez-Llodra[12], Silvia Bianchelli[16], Milanese Martina[17]
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MERCES is a EU project focused on the restoration of different degraded marine habitats, with the aim of: 1) assessing the potential of different technologies and approaches; 2) quantifying the returns in terms of ecosystems services and their socio-economic impacts; 3) defining the legal-policy and governance frameworks needed to optimize the effectiveness of the different restoration approaches. Specific aims include: a) improving existing, and developing new, restoration actions of degraded marine habitats; b) increasing the adaptation of EU degraded marine habitats to global change; c) enhancing marine ecosystem resilience and services; d) conducting cost-benefit analyses for marine restoration measures; e) creating new industrial targets and opportunities. To achieve these objectives MERCES created a multi-disciplinary consortium (28 Partners from 15 Countries) with skills in marine ecology, restoration, law, policy and governance, socio-economics, knowledge transfer and dissemination/communication. MERCES project consists of 10 Work packages on: the inventory of EU degraded marine habitats (WP1), pilot restoration experiments on soft and hard bottoms, including deep-sea ecosystems (WP2, WP3, WP4), and the effects of restoration on ecosystem services (WP5). The legal, policy and governance outputs will make effective the potential of marine restoration (WP6) and one dedicated WP will assess the socioeconomic returns of marine ecosystems' restoration (WP7). The transfer of knowledge and the links with the industrial stakeholders will be the focus of WP8 and the results of MERCES will be disseminated to the widest audience (WP9). The project will be managed through a dedicated management office (WP10). MERCES project will contribute to the Blue Growth by: i) improving the EU scientific knowledge on marine restoration, ii) contributing to EU Marine Directives; iii) implementing the Restoration Agenda, iv) enhancing the industrial capacity in this field, v) increasing the competitiveness of EU in the world market of restoration, and vi) offering new employment opportunities.

**S-10 -Developing resilient communities; Integrating restoration science & the built enviroment**

**S-10.1**

**The Regenerative Farm Observatory: Designing an Experiential Education Landscape to Teach Sustainable Agricultural Practices**

Ann Kearsley
Ann Kearsley Design / Northeastern University, PORTLAND, United States of America

Agriculture is a major contributor to global greenhouse gas emissions. Regenerative Agriculture is a holistic approach to land management developed to help reverse the negative environmental impacts of both plant and animal farming. Regenerative Agriculture employs farming practices that increase soil organic matter and soil fertility, and sequester carbon in both soils and aboveground biomass.
The Wolfe's Neck Center for Agricultural and the Environment (Maine, USA) recently established the Regenerative Farm Observatory, a demonstration and research center for net-zero carbon farming practices. WNC is a leader in sustainable farming and promoting agriculture and food-systems related education, research, recreation and community building. WNC is a working dairy where the farm operations are used to support numerous educational programs including Dairy Farmer Training, a Summer Farm Camp and a Teen Agriculture Program, as well as providing a year-round destination for school groups and environmental organizations. Working with the farmers and educational staff of WNC, landscape architect Ann Kearsley developed a masterplan to organize the physical integration of the farm's educational and recreational programming with the agricultural operations.
The masterplan includes an Experiential Education Landscape, an open pedestrian space linking major program areas like classrooms, the Dairy, livestock barns, pastures, crop fields, woodlands, ocean shoreline and a campground. The Experiential Education Landscape is where visitors learn about both the sustainable practices behind Regenerative Farming and the functional ecological and biological processes that make these practices successful. The challenge with designing a landscape that highlights the ecological processes supporting carbon sequestration, is that most of these critical processes take place in the soil - underground and out of sight.
This session will consider landscapes designed to connect people to the plant communities, biological processes and ecological function of their environment through experience and observation – landscapes designed to integrate science and the built environment.

**S-10.2**

**Designing a Waterfront with Ocean Restoration in Mind**

Marcha Johnson
NYCParks and City College of New York, FLUSHING, NY, United States of America

Contemporary coastal cultures face a number of challenges related to rising sea level. Many efforts are being considered to protect low lying development from floods and storms. Oceans, the Earth's life-support system, are in rapid decline from human actions. Conserving the oceans on city edges – their living populations, the processes which enable shores to adapt and rebuild themselves - seems often to be missing from the conversation about rethinking coastal cities. In the search for new models of science-guided, sustainable, ocean-ecology-conscious approaches to living near the shore, the Randall's Island Living Shoreline project is offered as an example.
Oceans are the direct recipients of many heavy metals and man-made complex pollutants eroded from historic urban landfills which were used to build level space next to the urban waterways. In the middle of NYC's urban estuary, The Randall's Island Park Alliance with NYC Parks, has an energy-efficient phytoremediation demonstration project in construction. They are trying to reduce soil Mercury, Lead and PAH's (carcinogenic compounds). In collaboration with scientist advisors including a coastal geologist, a physical oceanographer, a soil scientist and a botanist with phytoremediation expertise, the project is designed to:
1) protect the public using this park,
2) increase the soil's microbial community,
3) set up a 3-year soil testing / monitoring program,
4) employ a diverse mix of mostly NY native grasses, forbs, shrubs and tree species with phytoextraction, phytodegradation and stabilization capabilities,
5) establish coastal habitats,
6) illustrate a landscape which is adaptable to sea level rise and
7) engage the community as citizen scientists in better understanding sea level, urban soil pollution, its effect on oceans and ways to address it.
A long-term aim is to have vibrant coastal cultures which embrace, celebrate and support healthy oceans.

**S-10.3**

**Don't stick plasters, restore the system! Showcase: Accra, adaptive & attractive**

Steven Slabbers
Bosch Slabbers Landscape + Urban planning, THE HAGUE, Netherlands

This presentation is about restoring the natural system at the scale of the entire city and its surroundings. For the long term 'sticking plasters where it hurts' isn't a successful strategy, a system-wise approach is much more effective than working against the system. Analyze the natural system, when you know how it works you can work along with it.
Accra, capital of Ghana, is situated in the low area between hills and ocean, veined by numerous streams and rivers. To accelerate the run off of the water in the last decades these natural streams have been transformed in huge concrete drains.Nevertheless, water safety is still one of Accra's main problems; during and after heavy rains the city struggles with serious floods, causing unacceptable risks. Climate change makes the situation even worse, heavy rains occur more frequently. Urban expansion is another issue. Last decades Accra has gone through an accelerated growth, from less than 1 million inhabitants in 1985 to 4.7 million today. For the next twenty years again a doubling is expected, caused by the trek from the countryside to the city and the influx from refugees from surrounding countries.
Main challenge is to develop Accra 'adaptive and attractive' in such a way that water safety is strongly improved and the city can accommodate the doubling of population.Historically Accra puts all its cards on drainage. The existing system is based on the thought that you should always and anywhere drain as quick as possible.
This presentation stresses the need for a mind shift, based on the restoration of the entire natural system. Drainage is the last card to play. Retain and store as long as possible and only drain when no other option is left.

**O-11-Peatland/wetland restoration**

**O-11.1**

**Effect of top soil removal on in-situ methane emissions in a rewetted bog grassland**
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In many European countries, peatland rewetting has become an important measure to restore ecosystem functioning and to mitigate greenhouse gas emissions. However, rewetting degraded peatlands that were under intensive grassland use frequently results in high methane ($CH_4$) emissions. With incubation experiments it has been shown that the removal of the upper degraded peat layer can effectively reduce the potential for high $CH_4$ emissions under inundated conditions. To test this possibility in the field, we installed a field trial in a drained peat bog in north-western Germany. The trial consists of seven blocks (~8 x 24 m) representing the current state (intensive grassland use) as reference and six different restoration approaches. Four of the six restoration approaches represent rewetting after topsoil removal (TSR) down to two depths (~30 cm and ~60 cm). The remaining restoration trials include rewetting on the original surface with and without regular biomass harvesting, and spreading *Sphagnum* spp. propagules on half of the TSR blocks to initiate vegetation succession. On all seven blocks we measured $CH_4$ fluxes fortnightly using manual closed-chambers. After one year, $CH_4$ emissions of the blocks without TSR were similar to literature values of rewetted sites without TSR. Compared to rewetting on the original surface, TSR showed only very small $CH_4$ emissions that were reduced by several orders of magnitude. Spreading of fresh *Sphagnum* spp. propagules had only little effect on $CH_4$ emissions during the first year of establishment. In addition, we found that the reference block displayed high $CH_4$ emissions during the non-growing season suggesting that also the current land use can be a significant source of $CH_4$ during wet winters. Overall, these are the first field-scale results demonstrating that TSR likely is the most effective measure to prevent high $CH_4$ emissions after rewetting.

**O-11.2**

**Restoration of wetland habitats for biodiversity and plant and animal rescue**
Simona Casavecchia[1], Simone Pesaresi[1], Roberta Gasparri[1], Maurizio Bianchelli[2], Michele Rismondo[2], Fabio Taffetani[1], Edoardo Biondi[1]
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Wetlands are recognised as one of the most threatened habitats in the world and in particular in Mediterranean area. Because of the isolation of these habitats surrounded by an environmental matrix inhospitable for aquatic and hygrophilous species, they are subject to several pressures such as alien species invasion, draught, climate changes, anthropic disturbance etc.
Ponds and other wetland typologies host a considerable number of both animal and vegetal species that have become rare, and they are included in the international red lists of threatened species.
For this reason, conservation of these habitats is of primary importance and recovery actions are needed. In this context, we present three examples of wetland restorations carried out in central Italy aimed at conservation and improvement of biodiversity in territories subject to very strong anthropic pressures.

The first case study refers to the realization of three little ponds in a lowland close to the sea for the restoration of the habitat of the Italian green toad (*Bufo balearicus* Boettger, 1880). This is a species included in Annex IV of the Habitats Directive. The natural habitat of the Italian green toad has been destructed for the building of tourism facilities and this led to an infringement procedure by the European Community.
The second case study was aimed at the restoration of a wetland in an Italian Natural Park in order to reintroduce halo-hygrophilous species disappeared since a long time and improve the plant biodiversity of this natural area. Seeds and plants were collected in a wet area of the Gargano National Park where semi-halophilous ponds still occurs.
The last case study consists in the restoration of a hygrophilous wood in a sub coastal area in order to improve the ecological corridors for both animal and plants important for the implementation of the regional Ecological Network.

**O-11.3**

**The recovery of burbot (Lota lota) as a consequence and purpose for floodplain restoration**
Lore Vandamme, Johan Auwerx, Johan Coeck
INBO, BRUSSELS, Belgium

Rivers have been channelized worldwide. This impacts the aquatic ecosystem and the natural function of floodplains. The channelization reduces habitat diversity and with it aquatic life.
Adult burbots spawn in tributaries or long inundated fields. With no predators, little competition and plenty of food, natural floodplains offer the ideal habitat for larvae to grow. In the Flemish part of Belgium however, burbot disappeared in the 1950s. Channelization and declining water quality were to blame. Following improvement of both the water quality and required habitat structure, burbot was reintroduced in Flemish rivers in 2005. For an introduction to be successful, the fish need to be able to grow into mature adults and produce viable offspring to close the life cycle.
Natural recruitment of introduced burbot is monitored by INBO (The Institute for Nature and Forest Research) annually, financed by ANB (The Agency for Nature and Forest). In 2009 and 2012, juvenile burbot originating from natural reproduction was found. On top of that, four consecutive years starting from 2014 onwards, burbot larvae were found in a pool near a tributary of a lowland river, demonstrating natural reproduction as well.
Numerous projects to restore the natural river dynamics are being realized. The experience gained during this reintroduction of burbot has provided INBO with insights in the habitat conditions required for the reproduction and growth of burbot. Restoring natural floodplains and improving their connectivity with the river and its tributaries remain the most valuable solutions towards biodiversity and ecosystem integrity. In Flanders however, space is often a limiting factor. Temporarily connecting a suitable pool during spawning season, has been rewarded with the presence of burbot larvae several times already. These successes show us how we can further provide floodplains or alternatives and improve their accessibility to reassure a sustainable burbot population in Flanders.

**O-11.4**

**Succession of aquatic and wetland vegetation in disused sandpits**
Anna Müllerová
University of South Bohemia in Ceské Budejovice, CESKÉ BUDEJOVICE, Czech Republic

With expanding impact of human population, habitats suitable for endangered and rare species of plants and animals are continuously decreasing. Mining sites are a special type of an intervention into a landscape. Many studies address the succession of vegetation in post-mining sites however there is very few studies about succession and an importance of wetland and aquatic habitats in such sites. The aim of this study was to describe the development of aquatic and wetland vegetation in abandoned sand pits. Data collection was done in 2016, 2017 and 2018 in the form of phytosociological relevés all over the Czech Republic. The method of chronosequence was used for describing the changes in vegetation expressed by ordination methods. Alongside the vegetation composition several environmental characteristics (water depth, substrate type, and age) were recorded. This study is dealing with 60 sand pits ranging from 1 to 65 years since abandonment. Altogether 229 species of vascular plants were recorded in wetland and aquatic habitats. 39 species of Red List of vascular plants of the Czech Republic were found, with higher number of such species in periodically flooded sites than in permanently flooded sites. Water depth, age and substrate type have significant effect on plant species composition. Periodically flooded sites are usually progressing toward reed and high sedge stands which overgrow open areas. Dominant exchange, as is known in terrestrials or semiterrestrial succession, does not seem to work in permanently flooded sites. Sand pits in the Czech Republic are in general good model areas for near-natural restoration, especially favoured spontaneous succession. They can also provide habitats that are continuously disappearing from surrounding landscape and therefore act as a refugia for endangered species.

**O-11.5**

**Vegetation as a proxy for GHG emissions from peatlands: an update of the GEST-list**
John Couwenberg[1], Felix Reichelt[1], Gerald Jurasinski[2]
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Greenhouse Gas Emission Site Types (GESTs) were developed as a proxy to assess greenhouse gas (GHG) emissions and emission reductions from peatland rewetting projects in temperate continental Europe (Couwenberg et al. 2011). GESTs use vegetation as an integrative proxy for GHG fluxes. Vegetation is well suited for that purpose as it reflects long-term water tables, affects GHG emissions via assimilate supply and aerenchyma, and allows for fine-scaled mapping.
Many new flux measurements have become available since we first introduced the GEST approach. Whereas the original GESTs were based on 60, 140 and 128 annual flux measurements for $CO_2$, $CH_4$ and $N_2O$ respectively we now have 236, 339 and 272 measurements for evaluation.
We grouped flux data with data on vegetation, mean annual water table and other parameters, including land use, to arrive at classes that best describe GHG fluxes in association with a coherent set of site conditions. The resulting matrix allowed us to inter- and extrapolate flux values where direct measurements were not available.
We defined a total of 30 GESTs and 9 special GESTs, representing non-treed sites ranging from deeply drained to shallow flooded and nutrient poor to nutrient rich. Special GESTs represent aberrant sites for which GHG fluxes diverge from the general relationship with water table and vegetation or where the relationship between water table and vegetation is atypical. The special GESTs include sites with an only shallow peat layer that would not fit common definitions of peat soil (>30 cm thick layer with >35% organic material).
We present an overview of GESTs and the underlying meta-analysis of flux data.
Couwenberg J, Thiele A, Tanneberger F, Augustin J, Bärisch S, Dubovik D, Liashchynskaya N, Michaelis D, Minke M, Skuratovich A, Joosten H. 2011. Assessing greenhouse gas emissions from peatlands using vegetation as a proxy. Hydrobiologia, 674, 67-89.

**O-11.6**

**Spatial patter of plant cover on a large calcareous fen complex with ill-fated amelioration**
Mati Ilomets, Laimdota Truus, Kairi Sepp, Raimo Pajula
Tallinn University, TALLINN, Estonia

At the end of 19 century local landowners straighted and dredged by hand the streams throughflowing and feeding large (over 3500 ha in NW Estonia) Carex dominated Suursoo-Leidissoo calcareous fen complex. The expected result, to turn the site into productive hayland and pasture, failed. Later a part of the site was ditched for fuel peat excavation what never happened.
The management concept under the project LIFE15 CCM/DE/000138 “Reduction of CO2-emissions by restoring degraded peatlands in Northern European Lowland” is to restore the fen hydrology to the extent the system can again function as carbon sink. The prerequisite for that is detailed knowledge about spatial pattern of present plant cover, hydrology and substrate properties formed because of human impact. In summer 2017 vegetation was analysed on 14 cross-directional to ditches transects with lenght of some 200-500 m each. Using stratified approach, tree and shrub layer was analysed on 69 plots by 10x10m, field layer on 828 (1x1m) and surface layer on 2482 (25x25 cm) subplots. Plots covered variation of habitat types from insignificantly affected open calcareous fen (*Myrica gale+ Schoenus ferrugineous; Carex rostrata-C.elata- Menyanthes trifoliata*) over *Myrica gale-Molinia caespitosa* and *Calluna vulgaris- Eriophorum vaginatum-Sphagnum* communities to deeply drained peatland forests (*Pinus sylvestris-Betula pubescens-Vaccinium*-forest mosses group). Some 100 vascular plant species (incl. orchid species) and over 20 moss species were found. Close to every plot the depth to water is monitored, water samples for pH electrical conductivity, for peat properties (bulk density, ash, Ca, Mg Fe content in late fall) were taken. In the presentation we discuss not only about the relationship between species composition and abiotic parameters but wish to evaluate about the longer-term effects of improved hydrology on the vegetation.

**S-11 5-Forest restoration at multiple scales;from species & microsites to habitats & landscapes**

**S-11.1**

**Poor spatiotemporal connectivity limits the benefits of forest restoration to fungi; species restoration through translocation**
Jenni Nordén
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A large number of deadwood-dependent organisms, such as fungi and insects, can potentially benefit from restoration of previously managed forest through deadwood creation. However, rare, red-listed or naturalness indicator fungi may not be able to make use of restored forests because of poor spatiotemporal connectivity, small size of the created deadwood, or the selected tree species. Rare, specialist and red-listed wood-decomposer fungi are dependent on connectivity at the stand (high amount of suitable dead trees), landscape (good connectivity to old forests) and regional scales (short history of intensive land use), and need large naturally died downed trees, especially spruce, pine and aspen in boreal Finland and NW Russia. In a Scandinavian study, wood-decomposer fungi that are used as indicators of naturalness were dependent on connectivity of old forest (≥80 years) within 100 km. Indicator species increased and non-indicator species decreased in total abundance with the increasing age of

the local forest stand. Landscape-scale old-forest connectivity was beneficial for indicator species in all sites except those with relatively low amount of deadwood, while non-indicator species showed the opposite pattern. We identify a threshold of around 29 $m^3$ $ha^{-1}$ in the amount of spruce logs where indicator species become abundant enough to influence non-indicator species through competitive interactions. The indicator species did not need a long history without any logging operations or strong local deadwood continuity. To overcome the limitation by poor spatiotemporal connectivity, fungal species can be brought to the forest as active mycelia in wood plugs, as shown in a successful translocation experiment in Finland and an ongoing experiment in Norway. Translocation can be an efficient tool in bringing back the most threatened or ecologically important fungal species, but to benefit most of the original species in their primary habitat, increasing the amount of resources and spatiotemporal connectivity is critical.

**S-11.2**

**How to kill a tree? The way of creating dead wood matters**
Kaisa Junninen[1], Hannes Pasanen[2], Johanna Boberg[2], Shinichi Tatsumi[2], Jan Stenlid[2], Jari Kouki[2]
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Increasing the amount of dead wood, and thereby promoting habitats for saproxylic species, is one of the most commonly applied restorative treatments in boreal and temperate forests. We studied whether different tree-level treatments used for creating dead wood (girdling, chainsaw felling, and uprooting) have an effect on the wood-inhabiting fungi in the logs of Scots pine (*Pinus sylvestris*), and whether the structure (diversity and composition) of the fungal communities differ from those that occur in naturally uprooted pine trees. The study was conducted in Finland, within currently protected forests that have been previously managed for timber production. Both fungal DNA (for sequence-based identification) and the presence of sporocarps of polypore fungi were surveyed from the trunks. A greater number of species was associated with the girdled and subsequently fallen trees compared to the other types of dead wood. The method of felling trees (uprooting vs. chainsaw-felling) also resulted in differences in community composition, but this mainly concerned the sporocarp occurrence of polypore fungi. Fungal communities on naturally uprooted dead wood had more variation compared to the communities of restored logs. Overall, our results suggest that restoration of dead wood can provide substrates for many fungi, including red-listed polypores. However, to capture the variation in natural fungal communities, several methods should be used simultaneously when artificially increasing the amount of dead wood in forest ecosystems.

**S-11.3**

**Simulating effects of restoration efforts on suitability of forests for a locally endangered woodpecker**
Anouschka Hof[1], Joakim Hjältén[2]
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Habitat restoration is often implemented to mitigate the negative effects of intensive forestry on biodiversity. It may be increasingly adopted in future to alleviate additional negative effects of climate change. Ascertaining the restoration effort needed to fulfil project goals is difficult. Insights may be gained through simulating the effects of restoration efforts on landscape dynamics through time. Here we used a spatially explicit landscape simulation model to simulate the effects of different restoration efforts on forest landscapes in Sweden to assess the level of mitigation that is needed to allow viable populations of the locally critically endangered White-backed Woodpecker (*Dendrocopos leucotos*); an umbrella species whose protection may serve the protection of a range of other species. Based on the goals of the protection plan for the species, which reflect its habitat requirements, we evaluated which of several restoration scenarios could fulfil goals with respect to (1) the amount of deciduous forest; (2) the amount of dead wood; and (3) the age of the forest. We found that whereas it may be relatively easy and quick to acquire high levels of dead wood, increasing the proportions of deciduous forest and of old forests require considerably more time and effort. Also, current management actions would not be sufficient to create the required amount of habitat to conserve the White-backed Woodpecker in our study region. Simulations like ours can provide valuable information about the levels of restoration needed through time to fulfil project goals and may prevent wasting valuable resources, time, effort, and money.

**S-11.4**

**A history of clearcutting limits establishment of signal species, even close to natural forests**
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Estimates suggest that as much as 75% of forests in Norway have been clear-cut since the 1950s. We examined how this affect forest structure and forest biodiversity, by comparing two categories of forest dominated by *Picea abies*. Our aim was to investigate if specialist signal species occurrence differed between natural and managed forest stands.

One category was old, selectively-logged near-natural forest stands, and the other consisted of old forest stands previously clear-cut. The stands were mixed in a mosaic pattern in the forest landscape. In both forest categories, we sampled variables pertaining to forest structure as well as signal species of fungi and lichens.
We found that even though there are no difference in *volume* of deadwood in the two types, there were more signal species in the stands that have never been clearcut. This indicates that even in a landscape with relevant species within dispersal distance, the specialist species seem to struggle in the 'new' old stands, 70 years after clearcutting. The study points to the need for active restoration efforts in combination with changed management techniques and sufficient forest protection, as more and more of the remaining forest will be transformed by clearcutting practices.

**S-11.5**

**Forest restoration for biodiversity conservation: response of saproxylic beetles**
Joakim Hjältén[1], Ruaridh Hägglund[1], Therese Löfroth[1], Jean-Michel Roberge[1], Mats Dynesius[2], Jörgen Olsson[1], David Bell[1], Christer Nilsson[3], Dolly Jørgensen[4]
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Intensive management of boreal forest has caused declines in biodiversity and decrease in habitat quality for a large number of specialized species. We have reached a situation where we no longer can rely on passive conservation measures, i.e. setting aside conservation areas under a free development philosophy. Instead, to achieve conservation goals, we need methods for restoration of hitherto managed forest and forest reserves.
In two separate field experiments we evaluated the effect of three different restorations methods: 1) restoration burning, 2) gap cutting and 3) selective harvest to remove Norway spruce to benefit deciduous trees (originally intended to benefit white-backed woodpeckers) on saproxylic beetles, a group of insects severely threatened by modern forestry.
As predicted, saproxylic species known to be ï¬□re favoured increased dramatically after burning. The immediate response shows that, initially, ï¬□re favoured species are attracted from the surrounding landscape and not produced on site. Gap cutting increased the abundance of cambium consumers but had no signiï¬□cant immediate effect on total species richness or assemblage composition of saproxylic beetles. The stronger effect of burning compared to gap cutting on saproxylic assemblages is probably due to the very speciï¬□c conditions created by ï¬□res; attracting many disturbance-dependent species, but at the same time disfavouring some disturbance-sensitive species.
Selectively harvest to remove Norway spruce benefitted many species, especially species associated with sun exposure, but also species linked to dead wood from broadleaved trees. Red-listed saproxylic beetles showed a similar pattern with more species and individuals in restored sites. All three restoration methods clearly benefitted certain groups of saproxylic beetles, but to some degree different species. The implication of this is that several different restoration methods must be used to recreate/mimic natural disturbance regimes and the natural variation in boreal forest and thus benefit saproxylic species disfavoured by current even-aged silviculture

**S-11.6**

**Does boreal forest restoration increase the structural variability at the stand scale?**
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Ecological restoration of boreal forests aims at re-instating the structure and dynamics of forests that have been degraded by silvicultural management. Forest restoration mimics natural disturbance dynamics and brings back fire as a natural part of forests successional development. The stand diversity consists of variation in tree species composition, tree dimensions (dbh), and diversity in CWD positions (log, snag, broken), CWD dimensions, species and decay degree.
Using a 12-year large-scale field experiment conducted in two Natura 2000 areas along eastern Finland, we assessed how two alternative restoration methods (deadwood enrichment (DWE) and burning (B)) affect structural diversity of forests stands in comparison to untreated control ("passive restoration"). No trees were removed from the stands during or after the treatments. The measurements of stand structure have been conducted before and three times after restoration treatments during 2005-2017. The diversity of tree stand structure was calculated by classifying different wood objects into 'pseudo-species' and counting the number of different 'pseudo-species'.
In 11 years since restoration, restoration by B increased both the volume and diversity of deadwood, whereas DWE only increased the volume of deadwood, diversity was not greatly affected. Instead, the living tree diversity was more variable between stands, and was the highest in the untreated controls and lowest in the B. In the severely burned stands nearly all trees died within two years after treatments, imperiling the continuity of deadwood in the future. To conclude, restoration clearly speeds up the development of deadwood volumes and diversity needed to host large portions of biodiversity, but due to decrease in living trees' diversity, we suggest several restoration methods to be used simultaneously within the landscape, to ensure high variability in living stand structure and deadwood continuity in short term and in the future.

## W-4- Ecological restoration: Education, training, communication & opportunities for emplyability

### W-4.1

**Using participatory processes to define priority areas for restoration in a heterogeneous Mediterranean forest landscape**

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Mediterranean landscapes show different levels and types of degradation impairing the provision of ecosystem services (ES). Ecological restoration can reverse current degradation trends. Restoration projects in the Mediterranean region have commonly been developed by the environmental and forest Administration, with scarce intervention of other society sectors. However, stakeholder participation in land management may contribute to increase the efficiency and durability of the decisions, fostering citizens' engagement in restoration projects. Since 2016, we have carried out a research project aimed to develop tools for restoration planning in the Valencian Community (E Spain), using an integrative and inclusive approach. We carried out a participatory process to identify and weight the ES associated to landscape units in the Enguera Management Area, and the criteria to prioritize ecological restoration actions. The work area comprises 185.000 ha, covered by forest and shrubland (80%), and forest fires are the main disturbance.
We established a stakeholder platform integrated by a wide and representative sample of social profile. Stakeholders identified 23 ES and 21 prioritization criteria in face-to-face and online interviews. Ecosystem service *Maintenance of suitable habitats for flora and fauna* received the highest weighting coefficient, followed by *Provision of ground and surface water, Maintenance of soil fertility* and *Maintenance of air quality*. Socio-cultural services were generally perceived as less important than other types of ES. The most important prioritization criterions were *Fire risk*, *Fire recurrence*, *Erosion* and *Risk of flooding*. Conversely, *Accessibility* and *Proximity to residential areas* were poorly valued.
This information will be combined with available cartography through the identification of suitable indicators to produce a map of priority areas to restore ES.
We appreciate funding received from the Ministry of Economy, Industry and Competitiveness and European Regional Development Funds (FEDER), project 'Tools for planning ecological restoration in the Region of Valencia' (TERECOVA; CGL2014-52714-C2-1-R).

### W-4.2

**Knowledge transfer across regions, disciplines and stakeholders in riparian restoration: educational issues**

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Vegetation is a central component of riparian landscapes, modulating biological and physical processes and providing multiple ecosystem services yet subject to intense use and pressures that result in widespread degradation. Such degradation motivated restoration and mitigation projects but the scarce consideration of vegetation-mediated processes has prevented the effective improvement of the riparian status across Europe which remains generally poor. CONVERGES Cost Action (CA 16208, approved in June 2017) aims to improve knowledge conversion from science to practitioners and to integrate practitioners experiences and interests in the scientific community, by coordinating research and training efforts across Europe. The driving force of CONVERGES is contributing to bridge an existing misalignment of 'frames' which often challenges the multiple socioecological targets faced by riparian restoration. Misalignment refers to the ways in which individuals or organizations with different backgrounds, geographical origin, cultural contexts, or purpose, know and conceive such complex riparian systems and how their management should be implemented. Preliminary results show an increased development of knowledge production about riparian vegetation in the last decades, which has expanded across spatial scales (from microhabitat to hydrographic basin), gaining disciplinary depth (process-based, functional approaches), and including innovative tools (modelling and geomatics). In parallel, it is also confirmed that these knowledge production trends are not homogeneous across European regions, instead the knowledge remains geographically dispersed (i.e. East – West); and that produced knowledge is incompletely shared across sectors, an issue which limits comparability and transferability of outcomes and experiences. We will discuss how education and training activities will be used as a mean to bridge the gap between disciplines, actors and regions.

### W-4.3

**The difficult step from awareness to action**

Guðrún Schmidt

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For successful protection and reclamation of the local environment, it is critical to raise individual awareness and practice public participation. However, sustainable development requires also that we consider the problems of ecosystem degradation on a global scale through the effects of our consumption and lifestyle. The United Nations have accentuated that we need a transformation of society if we want to step towards sustainable development. Such a transformation can be facilitated through politics, financial inducements and technological innovation, but the key to real progress towards sustainability are changes in thinking, values and the way of living.
Numerous studies emphasized that rising environmental awareness alone is not enough to get people to practice a more environmentally friendly lifestyle and that we need a major change of what we consider as core values now and in the future. Such values and competences for moving society towards sustainability can be promoted by *education for sustainable development* (ESD) both for children and adults. ESD is based on a constructive understanding of education and relies on methods supporting participatory, constructive, reflective and discursive learning. ESD is intended to promote key competences such as participation, critical thinking, empathy, problem solving, complex and interdisciplinary thinking which all together should lead to action competence.
This presentation will show the importance of the global perspective we need to address land degradation and other big challenges of sustainable development. Some examples of ESD projects will demonstrate effective ways to teach how land degradation is linked with the wider context of sustainable development and climate change, and how ESD aims to help people in acquiring action competence and take a step towards a change in thinking and lifestyle.

**W-4.4**

**An educational programme for Icelandic Eco schools on restoring eroded land**

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An ecological restoration project for students in Eco schools in Iceland has been operated since 2013. It started with three primary schools but now eight schools participate in the project; five primary schools and three secondary schools. Landvernd, a non-governmental organization (landvernd.is/en), leads the project in collaboration with the Soil Conservation Service of Iceland (SCSI). This project increases teachers' capacities to teach complex environmental problems and gives students hands-on ecological restoration tools they can use to combat land degradation, climate change and loss of biodiversity. The project gives students and their teachers a platform to discuss and gain knowledge about these topics.
Pupils, aged 11-20 years, under the guidance of teachers, Landvernd and SCSI staff, set up restoration experiments on eroded areas near their schools. The experiments contain a control and five different treatments: hay mulch, fertiliser, grass seed and fertiliser, sheep manure and organic waste from the respective school. Using scientific methodology, the pupils monitor changes in vegetation cover and biodiversity and learn which treatments work best in their area. Furthermore, they gain understanding on the ecological processes that are activated with different treatments. The pupils themselves process the data and present their results to their schools and local communities.
A new workbook has just been published with educational material and 27 assignments guiding the students through the whole project, step by step. Amusing drawings and illustrations decorate the workbook and makes the material approachable. Using the workbook, the students practice and prepare for the field work in the class room, they get organised and confident when going in the field and receive guidance when processing and presenting the data. The workbook is free and available online. It offers a new educational tool to be used to tackle complex environmental issues in schools in Iceland.

**W-4.5**

**Examining the Language and Potential Environmental Consequences of Media Coverage of California Wildfires**

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What the public learns from the media matters. This paper compares the language online news media outlets employ when covering wildfires that more directly affect humans with language in coverage of wildfires that less directly affect humans by scrutinizing media coverage of two recent (2015) California wildfires – the Rocky Fire and the Valley Fire. This analysis reveals that regional news sources are especially focused on personal stories of the fires and their aftermath, whereas national and global sources, by nature of their circulation, view the situation more impersonally. Through agenda-setting, framing, and priming, the media selects what to, or what *not* to, report. In the stories that are covered, the media also prescribes a viewpoint when it reports a story. This paper explores diction choices and employs topic modeling to investigate media frames on wildfire and finds that, when covering stories (in this case, wildfires) that contain an element of human risk and suffering, the media employs a more emotional and negative tone. Sensationalizing and vilifying wildfire may redirect focus, perhaps in lieu of scrutinizing potentially lackluster fire safety protocols – for example, only one article of the 276 retrieved mentions poor and insufficient forest management as a reason for fire. Furthermore, the media's frame: belies an ignorance of humanity's long-

standing relationship with fire; overlooks the beneficial ecological effects of wildfire; and prevents the public from gaining important insight into the effects of climate change, as wildfires often aren't identified in news reporting as a consequence of global climate change. This research is important and relevant due to the current media climate surrounding "fake news" where there is growing discomfort with media agendas and influences, as well as recent initiatives to let forests burn freely for restoration and positive ecological purposes.

**W-5 Chief ecosystem officiers - and how the enable consortium works to educate these**

Chairs: Eva Rood and Berglind Orradottir

Workshop summary:
In this interactive workshop, participants will be engaged in solving a landscape restoration case by combining knowledge from economy and ecology. They will learn why bridging these two worlds is the best way to accelerate effective landscape restoration and sustainable land management with a business approach.

**S-12-Nature's little helpers; the role of cyanobacteria in ecosystem restoration**

**S-12.1**

**Soil restoration by cyanobacteria inoculation: relationship between cyanobacterial polysaccharidic matrix and soil properties**
Sonia Chamizo, Gianmarco Mugnai, Alessandra Adessi, Andrea Simiani, Federico Rossi, Roberto De Philippis
University of Florence, FIRENZE, Italy

Inoculation of soils with cyanobacteria is proposed as a sustainable biotechnological technique for restoration of degraded areas in drylands due to the important role that cyanobacteria and the exopolysaccharides (EPS) they secrete play in the environment. Cyanobacterial EPS increase the soil organic carbon pool and improve aggregation and porosity, thus favoring infiltration and water retention and improving soil water status and soil fertility. Cyanobacteria filaments and their EPS strongly increase soil stability, improving soil resistance to wind and water erosion. Cyanobacteria inoculation was demonstrated to artificially determine the development of biocrusts. So far, only a few studies have explored the relationships between the characteristics of the cyanobacterial polysaccharidic matrix, the development of artificially inoculated biocrusts, and their effects on soil properties. This information is crucial to select the most suitable cyanobacterial candidates for restoration of damaged dryland areas. The objective of this study was to examine the growth curve of two cyanobacteria species, *Phormidium ambiguum* (non N-fixing) and *Scytonema javanicum* (N-fixing), and the effects of their inoculation on biocrust development and soil properties in different textured soils, under laboratory conditions. The macromolecular and chemical characterization of the polysaccharidic matrix developed by both species on the inoculated soils was also analyzed. Cyanobacteria inoculation led to a more significant improvement in soil fertility properties in the soils with initially lower physico-chemical quality. *S. javanicum* promoted a higher increase in soil organic carbon and nitrogen content, likely associated to the higher amount of water-soluble EPS synthesized by this species, while *P. ambiguum* was more effective in increasing soil surface resistance, likely associated to the larger amount of EPS less soluble and with a higher degree of condensation synthesized by this cyanobacterium. Our results highlight the importance of the cyanobacterial polysaccharidic matrix for biocrust development and its role in improving soil properties and functions.

**S-12.2**

**Restoring biocrusts: a general strategy and an overview of emerging results**
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Biocrusts are a photosynthetic microvegetation inhabiting soil surfaces, composed of any combination of cyanobacteria, mosses and lichens. Biocrusts influence ecosystems by protecting soil against erosion, building soil fertility, and influencing hydrology. Thus, biocrusts potentially have high ecological restoration value. We envision a three step strategy in the development and deployment of these materials: 1. Optimizing *ex-situ* production of biocrust propagules, 2. Developing application strategies to enhance field establishment, 3. Developing and testing deployment technologies. Biocrusts can be rapidly cultured in greenhouse conditions for use in field settings. Cyanobacteria and mosses are generally amenable to culture, requiring as little as 2 months to yield a 5-fold increase in some species. Cultured biocrusts can survive in some field settings, but failure is common. Field survivorship and establishment is likely determined by the field-readiness (e.g., degree of hardening) of the artificially grown propagules, initial levels of stress experienced in the field, and whether propagules adhere to the soil.

Hardening greenhouse-reared biocrust organisms has not been successful to date, but our efforts are not yet comprehensive. To simultaneously upscale production and provide greater field hardiness, we are transitioning to outdoor biocrust cultivation methods where hardening could occur throughout the production process. Other approaches to enhancing field survivorship include temporarily reducing stress at the site of application, or minimizing re-transport of applied propagules. Application of biocrust materials may simply be achieved through broadcast of dry propagules; attempts to use a drill seeder for dispersal failed. Hydroseeding, and application of biocrust-bearing cloth are being tested. Using this three step strategy for methods development and deployment, we may solve remaining barriers and move forward to step 4: Integration of biocrust restoration with other restoration practices. An improved capacity to restore these foundational communities would have myriad benefits to restoration efforts for a wide range of ecosystems.

**S-12.3**

**Harnessing biocrust cyanobacteria for dryland restoration: effects on recruitment of native plants and soil function**

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Despite the widely-accepted importance of drylands - which store 45% of the global carbon and comprise a third of global biodiversity hotspots - and the large amounts of money invested in restoration, success rates are generally low. Given the large scale of restoration required, and severe deficits of locally-sourced soil materials that contain beneficial nutrients, microbes and a residual soil seedbank, direct seeding is often needed for reinstating biodiverse vegetation communities. However, seed-based restoration is extremely inefficient, and rates or seed mortality are frequently above 90%. Cyanobacteria from soil biocrusts have the capacity to act as bio fertilizers by promoting growth of certain plant species, and contribute to multiple key ecosystem services and functions in desert ecosystems including soil structure, stability, improved surface hydrology, C sequestration, and N fixation. These organisms can survive extreme conditions such as low precipitation, high solar radiation and extreme temperatures. However, despite their global importance, and their many environmental applications, the potential of cyanobacteria for ecosystem restoration in drylands, is yet to be harnessed. Here, we investigated i) the effects of bio-priming seeds of native plants used in restoration with a consortium of cyanobacteria species, on seed germination, seedling recruitment and growth; and, ii) the potential of inoculating cyanobacteria on soil substrates used in dryland restoration, including topsoil and mine waste, to restore soil functions such as soil carbon sequestration. Our results showed that cyanobacteria does not inhibit and can promote germination and early seedling growth of native arid species - phases known to be problematic for restoration success in dryland ecosystems. We also found that cyanobacteria inoculation can rapidly modify properties of reconstructed soil substrates such as increased soil carbon, underpinning the potential key role of these organisms as bio-tools to initiate recovery of soil functions in infertile, reconstructed soil substrates.

**S-12.4**

**Ecological dermatology: products to restore desert soil skin to its natural state and beauty**

Ferran Garcia-Pichel
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Biological soil crust communities, the soil skin of arid lands, provide important ecosystem services, particularly regarding soil fertility and stability against erosion. In North America, and in many other areas of the globe, increasingly intense human activities, ranging from cattle grazing to military training, have resulted in the significant deterioration of biological soil surface cover of soils. With the intent of attaining sustainable land use practices, we are conducting a 5-year, multi-institutional research effort to develop feasible soil crust restoration strategies for US military lands. We are including field sites of varying climatic regions (warm and cold deserts, in the Chihuahuan Desert and in the Great Basin, respectively) and varying edaphic characteristics (sandy and silty soils in each). To enable this effort, we have successfully established “biocrust nurseries” that produce viable and pedigreed inoculum, as a supply center for biocrust restoration, and for research and development. We report on significant advances made on optimizing methodologies for the large-scale supply of inoculum based on a) pedigreed laboratory cultures that match the microbial community structure of the original sites, and b) “in soil” biomass enhancement, whereby small amounts of local crusts are nursed under greenhouse conditions to yield hundred-fold increases in biomass without altering significantly community structure. We will also briefly report on current field trials using both types of inoculum.

**S-12.5**

**Biocrust inoculum development and soil stabilization strategies to promote biocrust restoration**

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Due to the importance of biological soil crusts (biocrust) communities to the ecological functioning of dryland ecosystems, there is keen interest in restoration of these communities after soil surface disturbance. Active biocrust rehabilitation, however, has remained difficult to achieve, because of questions of how to create biocrust inoculum and how to ensure the success of that inoculum in the environment. In a series of experiments, we examined the effects of biocrust inoculum type and soil stabilization strategies on biocrust development in disturbed soils at cool and hot desert sites in the Western United States. We inoculated disturbed soils with 3 types of biocrust inoculum: field collected (FC), which was biocrust that was collected at the site, mixed, and redistributed across plots; local biomass (LB) inoculum that was grown in the greenhouse under optimal soil moisture, temperature, and nutrient conditions from small samples collected in the field; and mixed isolate (MI) inoculum that was created in the laboratory from cyanobacterial cultures collected at the site. Experimental disturbance consisted of scraping the top 3 cm of the soil surface and then trampling with at least one pass of foot traffic. The soil removed in the scraping was used as the FC inoculum. Plots were prepared with two soil stabilization strategies. Straw checkerboards, in which straw served as silt fences, were installed in 3 x 1 m plots. In a second stabilization approach, polyacrylamide was applied to the soil surface in plots of the same size. The study was carried out in a factorial design of inoculum type by soil stabilization strategy on two soil types. We report on biocrust development and soil stabilization after two years. We discuss our success in creating biocrust inoculum and results from the multifactorial experiments in the context of conducting larger scale biocrust restoration in dryland ecosystems.

**S-12.6**

**Ecological restoration of biological soil crust in a phosphate mine area under arid conditions**

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Land-use changes affect key aspects of earth-system functioning, alter ecosystem services, and degrade the ability of biological systems to support human needs and quality of life. They also present us with a dilemma: on one hand, many land-use practices are essential for human needs, providing food, industrial inputs, natural resources and ecosystem services, while on the other hand, some land-use practices degrade the ecosystems and services upon which we depend. Studying the interactions between land-use changes and land function is important mainly to identify vulnerability to ecological management and restoration processes, which are needed in order to revert a degraded state to a restored or functional state.
The soil surface in undisturbed arid and semiarid systems, worldwide, is mainly covered with biological soil crusts (biocrusts), which contribute ecological services, such as soil surface stabilization and soil nitrogen enrichment, and act as primary producers for desert life food chains.
In the mining areas of the Negev highland, vast areas of soil surface were removed with the biocrust cover in order to expose the phosphatic rock for human use. This initiated extensive soil degradation processes.
In order to promote the ecological restoration, former mining fields are re-covered as part of a landscape restoration activity. The top soil cover is placed on the mining strip again.
Furthermore, we established a long-term experiment to examine different treatments, including biocrust inoculation, for soil surface restoration. We measured biocrust indicators for their restoration rate. It was found that the recovery of the local cyanobacterial crusts, in the reconstructed treatments, is in the process of gradual rehabilitation, and the rate of rehabilitation depends on local climatic conditions.

**S-13-Trait-based ecosystem engineering-using plant traits in recovery of ecosystem functions & services**

**S-13.1**

**The restoration of functional biodiversity in agro-ecosystems: field margin vegetation and crop herbivore regulation**

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Non-crop vegetation of field margins provides several habitat functions for natural enemies of crop herbivores. Since plant species differ such habitat functions, the floristic composition of non-crop habitats may be a key factor in crop herbivore regulation. The identification of plant traits that are related to biocontrol would facilitate the restoration of ecosystem services by sowing or planting but our understanding of plant-insect interactions is still insufficient to

replace a species-based by a trait-based approach.
We present a correlative study analysing 64 sites to relate plant species composition with crop herbivore and natural enemy abundance in crop fields and field margins (wheat, oilseed rape). We further used existing knowledge on candidate plant traits to develop a suppressive wild flower strip mixture. This mixture was sown to field margins and compared with a commonly used grass mixture and spontaneous vegetation in a factorial experiment. Herbivores and natural enemies were monitored in the field margins and inside the crop fields. Cover and phenological stage of all vascular plants were recorded in the field margins.
The correlative study demonstrated a positive relationship between the cover of nectariferous plant species that were flowering at the survey date and response variables related to herbivore regulation. The cover of wild poaceae (attracting several wheat herbivores) had only a small influence on regulation in wheat whereas wild brassicaceae (attracting many oilseed rape herbivores) increased herbivory in oilseed rape. In the factorial experiment, the wildflower strips containing a high density of nectariferous plant species attracted a higher number of natural enemies than grass strips or young spontaneous vegetation resulting in a higher abundance in adjacent crop fields. In both crops, a corresponding positive effect on aphid regulation was found. However, other dominant crop herbivores such as cereal leaf beetles and pollen beetles were not different between strip types.

**S-13.2**

**Using functional traits to create priority effects as a tool to steer restoration of grasslands**
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Knowledge transfer from science to ecological restoration and vice versa has improved in recent years, especially in the field of community assembly & succession as well as functional biodiversity (Temperton et al. 2004, Funk et al. 2008, Wainwright et al. 2018). We know from biodiversity-ecosystem functioning experiments worldwide that higher plant species and functional trait diversity often lead to better functioning of ecosystems (at least in terrestrial ones) but we do not yet know as much about how timing of arrival during assembly affects ecosystem functioning and hence restoration.
Species-rich grasslands are severely threatened by both agricultural intensification and land abandonment. We tested whether priority effects of order of arrival can be used to create more productive yet still diverse grasslands that motivate both farmers and conservationists. We set up a series of experiments to see whether priority effects occur in different kinds of grasslands and how the traits of the species may affect the outcome.
A mesic grassland field experiment combined biodiversity and assembly approaches studying the effect of order of arrival of three plant functional groups (PFGs: grasses, legumes and forbs) and of sowing low / high diversity mixtures on species composition, aboveground and belowground biomass. Sowing legumes first created priority effects with higher aboveground and lower belowground biomass. Priority effects seem to be more consistent below than aboveground, indicating an asynchrony between processes below and aboveground which may have repercussions on ecosystem functioning as well as service provision.
Recent experiments in dry acidic grasslands in mesocosms show that priority effects belowground on root biomass caused by time of arrival of plant functional groups were very similar to in the mesic grassland, whereas the patterns *aboveground* were very different. Both PFG order of arrival and sown diversity also affected the functional group and species composition of the communities.

**S-13.3**

**Invasion of a legume ecosystem engineer in a cold biome alters plant biodiversity.**
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Utilization of non-native plant ecosystem engineers is a worldwide strategy to combat land degradation. However, the ability of ecosystem engineers to modulate limiting abiotic and biotic resources can cause damage to ecosystems in which they become invasive. Here we study the transforming potential of nitrogen fixing herbaceous plants in a sub-polar oceanic climate. *L. nootkatensis* was introduced to Iceland in the 1940s to address erosion problems and foster reforestation. It became a high-latitude invader.
In a field survey, we quantified the impact of *L. nootkatensis* invasion upon native plant diversity, richness and community composition of heath-, wood- and grasslands. Afterwards, we scaled impacts up to the landscape level by relating occurrences of *L. nootkatensis* to environmental and human mediated variables across Iceland using a species distribution model.
Plant diversity was deteriorated under high lupine cover of the heath- and woodland. Plant species richness of the most diverse habitat, the heathland, linearly decreased with lupine cover. The abundance of small rosettes, cushion plants, orchids and small woody long-lived plants of the heath declined with invader presence, while the abundance of late successional species and widespread nitrophilous ruderals in wood- and grasslands increased. Our species distribution model revealed 13.3% of Iceland's land surface area to be suitable lupine habitat. Until 2061–2080, this area will more than double and expand significantly into the Central Highlands.

Species-rich habitats showed a loss of plant species diversity and richness as well as a change in community composition under lupine presence. The future increase of suitable lupine habitat might lead to the displacement and eventual extinction of cold-adapted native plant species and will certainly challenge conservation as well as restoration of ecosystems in cold climates. Lupine invasion speeds up succession, which may be additive with climate change effects, and therewith accelerates ecological change in cold biomes.

**S-13.4**

**Leaf nutrient contents not specific leaf area increase rapidly and predictably in response to eutrophication**
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Theory predicts that plant functional traits rather than species composition, provide a common currency for understanding how anthropogenic pressures such as eutrophication and reduced herbivory impact on the functioning of grasslands. Here we show for the first time in a global experimental network at 27 grassland sites in four countries that one of the most commonly measured leaf traits, specific leaf area (SLA, a composite measure of leaf area per unit mass), does not increase significantly across fertilizer and herbivore exclusion treatments as theory predicts. Leaf nitrogen, phosphorus and potassium content did increase in response to soil nutrient addition, but contrary to expectations we found little significant increase when vertebrate consumers were excluded. We also found significant context-dependency in how leaf traits changed depending on species turnover over time in response to treatments, and climatic and soil nutrient conditions. We reveal generalizable local response syndromes where plants (explained by combinations of intraspecific and interspecific trait variation) change physiologically without necessarily investing differently in leaf area and leaf tissue, suggesting that leaf traits like SLA may not be reflections of adaptation to short-term perturbations.

**S-13.5**

**Grassland type and grazing intensity jointly shape grazing effects on grassland biodiversity**
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In the Palaearctic steppe zone, overgrazing was recently identified as one of the key drivers of declining grassland biodiversity. This underlines the necessity of the functional evaluation of increased grazing pressure on vegetation characteristics displaying decisive ecosystems functions. We tested the following three hypotheses: (i) 'Habitat-dependent effects of intensity': The effect of grazing intensity on species- and functional diversity is strongly habitat dependent. (ii) 'Intensity-dependent selectivity': The magnitude of diet selectivity of grazers decreases with increasing grazing intensity. (iii) 'Intensity-dependent evenness': Increasing grazing intensity increases evenness and functional evenness of plant communities. We analysed trait-based vegetation patterns in four types of grasslands (Dry alkali short-grass steppes, Dry loess steppes, Non-alkali wet grasslands and Alkali wet grasslands) along an intensity gradient of beef cattle grazing at 73 sites in Hungary. Basic vegetation characteristics (species richness, Shannon diversity and evenness) and four leaf traits (leaf area, specific leaf area, leaf dry weight and leaf dry matter content) were considered in the analyses. We calculated community weighted means (CWM) for each trait, and multi-trait functional richness (FRic), functional evenness (FEve) and divergence (FDiv) for all studied leaf traits. Most of the vegetation characteristics were affected by both grazing intensity and grassland type and some also by their interaction. With increasing intensity the overall selectivity of grazing decreased, but the changes in evenness and functional evenness were strongly habitat dependent. We stress that one-size-fits-all strategies and decisions cannot be recommended and actions should be fine-tuned at least at the level of grassland type. The species-rich dry loess steppes were the most vulnerable even to the slightest increase of grazing intensity. We stress that the conservation of these types of grasslands needs the most careful implementation and planning.

**S-13.6**

**How are functional traits related to the invasibility of a restored plant community?**
Jennifer Funk[1], Sarah Kimball[2], Travis Huxman[2], Megan Lulow[2], Gregory Vose[2]
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Trait-based ecology has emerged as an effective method for predicting population dynamics, outcomes of competitive interactions, and response to global change, using a few simple measurements that are available in online databases. Yet trait values scaled to the community level have failed to reveal universal patterns regarding community persistence. This is particularly important in restoration ecology, where a common goal is to establish a native community that is resilient to invasive species. Here, we use existing large-scale ecological restoration efforts in southern California, combined with metrics of subsequent invasibility and trait values of natives to identify trait

values that most strongly influence invasibility. We established plots in two different ecosystems: coastal sage scrub and grassland. We used seven unique seed mixes, including four in the coastal sage scrub community (grasses, forbs, shrubs, and all combined), and three in the grassland community (grasses, forbs, and both combined). We measured the number of seedlings and adults, and several performance metrics for *Brassica nigra* (the most abundant non-native species at our study site). We collected seed, leaf, and root trait data on adult plants near the restoration site. Species mix influenced invasion resistance, but this was more strongly tied to life history (e.g., shrub, forb) than functional traits. Overall, native grasses provided the weakest resistance to invasion. Functional dispersion and community weighted mean trait values showed few correlations with *B. nigra* performance. Plots with high carbon assimilation traits resulted in high invader performance. Plots with low specific leaf area, thick roots, and big root systems (e.g., shrubs) resulted in high invader density and low individual invader biomass. It is possible that the more stress-tolerant native shrubs were most resistant to invasion because they are best able to survive despite resource extraction by invaders.

## S-14 -Restoring natural landscapes in urban & urbanizing areas

### S-14.1

**Integrated Restoration Prioritization: A Tool for Prioritizing Restoration**
Andrew Ramesbottom, John Stille, Ralph Toninger, Namrata Shrestha
Toronto and Region Conservation Authority (TRCA), TORONTO, Canada

Ecosystem restoration planning requires an integrated approach considering many components of the natural system when prioritizing where and what to restore. Toronto and Region Conservation Authority (TRCA) and partners have developed a strategic approach to restoration planning, using the concept of applied science to inform meaningful implementation decisions focusing on priority areas rather than opportunism. Through various long term monitoring and modelling initiatives, TRCA has amassed a wealth of knowledge and data on terrestrial biodiversity, aquatic ecosystems, and hydrology. Consolidating these data sets to compare discrete areas based on different parameters and thresholds have helped direct future restoration initiatives. The Integrated Restoration Prioritization (IRP) framework uses existing data to reflect different restoration goals, ensuring important habitats and corridor linkages are protected, enhanced or rehabilitated. This is achieved by identifying where impairments to ecological function are located and prioritizing upstream and local catchments that could contribute most to improving the existing natural heritage system. The IRP is a multi-benefit, multi-discipline approach to restoration planning, where entire reaches, or catchments, are considered for strategic implementation and monitoring. This approach has proven successful for garnering support through new partnerships and securing funding which has resulted in measurable improvements to the natural system. This presentation will demonstrate how IRP can be used as a tool to successfully achieve different natural resource planning objectives.

### S-14.2

**Striving to Restore a Living City - Ecosystem Compensation in the Urban Environment**
Kelly Jamieson, John Stille, Noah Gaetz, Ralph Toninger
Toronto and Region Conservation Authority, WOODBRIDGE, Canada

As urban development in Southern Ontario (Canada) grows, increased stress is placed on existing natural systems, impacting their ability to provide ecosystem services to an increasing population. Conservation in an urban context is challenging because of the finite space available for natural systems. Issues at a larger scale, such as global climate change, highlight the need for natural feature conservation and building natural system resiliency. Despite a strong protective policy and regulatory regime, natural features and the functions and services they provide continue to decline within the Toronto region. Within this context, ecosystem compensation through restoration becomes an important mechanism to help ensure that critical ecosystem functions and services lost through development are replaced on the landscape.
To date compensation restoration has resulted in some success. However, there are a number of challenges, including the limited availability of public lands for restoration, the risk and uncertainty associated with restoration, lengthy negotiations, lack of transparency, and inconsistent outcomes. Toronto and Region Conservation Authority (TRCA) engages in the compensation process as a landowner, regulator, proponent, and provider of compensation restoration. As such, TRCA is addressing these challenges by formalizing a compensation process that sets out principles and standards to ensure compensation decisions are strategic and outcomes are documented, tracked, and reported. The principles and standards are intended to ensure that compensation remains a last resort and that all efforts for protection on site are exhausted prior to contemplating removals. Standards of practice also help ensure that compensation is transparent, consistent, replicable, and aims to fully replace natural feature losses with on-the-ground ecosystem restoration. Tools have been developed to ensure that this restoration is strategic, prompt, and guided by current science and natural system objectives. This compensation framework is intended to ensure projects are appropriately financed and successfully implemented for long term conservation.

### S-14.3

**Restoring an Urban Creek using Natural Channel Design**

Ryan Bolton, Karen McDonald
Toronto and Region Conservation Authority, WOODBRIDGE, Canada

Toronto and Region Conservation Authority (TRCA) are a global leader in ecological restoration making us one of the leaders in habitat restoration in The Greater Toronto Area. As such, there have been many successes and lessons learned regarding natural channel design and construction. Over time, restoration practices have evolved to reflect a more integrated approach where multiple techniques are utilized to achieve greater gains in overall natural system health. Current restoration objectives are rooted in improving ecological function, increasing natural cover and providing new habitat opportunities for fish and wildlife. Previous restoration practices often focused on rehabilitating isolated features to solve a singular issue with little consideration for associated cover types or features within surrounding areas. For example, a stream erosion project might have focused only on hard stabilization treatments to protect against severe erosion without including the benefits of associated habitat features or including flood mitigation through floodplain restoration. A more holistic approach to natural channel design is critical to achieving strengthened natural system resiliency especially in urban and near urban land-uses. A reach based approach to restoration includes design and implementation considerations that include a more natural stream alignment accounting for varying flow regimes, bank stabilization, natural channel migration, storm water management, wildlife habitat structures, riparian planting and public use. This presentation will look at TRCA's approach to natural channel design and implementation by providing an overview of current design considerations and construction practices. Examples will include a look at completed projects of channel re-naturalization and valley restoration to demonstrate how different techniques are applied in overall design and construction to achieve successful project outcomes.

**S-14.4**

**Re-imagining Utility Corridors as Linear Habitat**

Katie Turnbull
Toronto and Region Conservation Authority, WOODBRIDGE, Canada

The Scarborough Centre Butterfly Trail is emerging as one of the most innovative meadow revitalization projects in Canada. Over the past 5 years, the Toronto and Region Conservation Authority (TRCA) in partnership with the City of Toronto and The W. Garfield Weston Foundation, have worked together to establish native meadows on lands within an Electrical Utility Corridor in Toronto, Ontario. This 3.5 kilometer stretch of publicly accessible greenspace which previously consisted of mown turf grass is now a thriving meadow with native wildflowers, grasses, berry producing shrubs, and songbird boxes.
This project was intended to be applied as a model that could be replicated across the Greater Toronto Area (GTA). There is a growing interest in restoring meadows within urban areas, expressed not only by TRCA and the City of Toronto, but by other municipalities, agencies and local communities. The three main project objectives are: to improve the natural cover of the area for wildlife and increase biodiversity; to improve the aesthetic appeal of the site for trail and park users with the establishment of native wildflowers and grasses; and to decrease the maintenance costs of continuously mowing 40hectares of Electrical Utility Corridor.
Electrical Utility Corridor are vast and important greenway connections to existing natural habitats within the GTA. Multi-use trails are becoming more common within utility corridor as important transportation connections for people travelling from one place to another. Typically utility corridors are mowed in order to maintain access to power lines and vegetation is cleared to prevent trees and shrubs from obstructing these areas. Meadows are an excellent alternative to mowed grass, remaining compatible with utility corridor management requirements and other land uses. By re-imagining electrical utility corridors as linear habitat, cities across the world could look to incorporating similar restoration projects.

**S-14.5**

**Habitat Creation and Enhancement in Canada's largest city: Tommy Thompson Park**

Karen McDonald, Andrea Chreston, John DiRocco, Gord MacPherson
Toronto and Region Conservation Authority, DOWNSVIEW, Canada

Tommy Thompson Park (Leslie Street Spit) is a 471 ha man-made park near downtown Toronto, Canada. It was never intended to be a public urban park, but through natural succession and strategic habitat enhancement and creation projects, it has turned into the most significant natural area on Toronto's central waterfront. Once it was determined the reclaimed land was not required for port-related facilities, the Toronto and Region Conservation Authority (TRCA) developed a Master Plan to help guide park development and management, and set out to restore some of the habitats that have been historically lost from the Toronto waterfront. The restoration and enhancement of more than 30 hectares of wetland and terrestrial habitat, plus over two kilometres of shoreline as well as deep water enhancements, have created a biological centre of organization in a highly urbanized environment, benefiting not only fish and wildlife, but the people who visit as well. The restoration and management of the site are not without challenges, which include invasive species, colonial waterbirds, fisheries and people. Receiving over 250,000 visits each year, human management is essential to ensure the ecological integrity of the site is maintained.

Well planned infrastructure, 18 kilometers of trails and nature-driven special events help the public understand, appreciate and steward Toronto's urban wilderness.

**S-14.6**

**Nature in an urban environment: Restoration of rare wetland habitats involving local communities in Israel**
Liav Shalem
Landscape architect and ecologist, TEL AVIV, Israel

Natural open spaces in Israel are dwindling due to population growth and increasing urbanization, increasing the threat to habitats and biodiversity. Rain pool and winter pond habitats are found mainly in the central coastal plain of Israel, where most of the urban development is concentrated, and over 90% of these habitats disappeared from this region.
The projects reviewed are the result of a study carried out at Tel Aviv University, in which different models of habitat rehabilitation were examined. The findings on rehabilitating perturbed habitats and reinforcing local biodiversity proved successful. It requires substantially reducing the seed bank of unwanted plants and reinforcing target species by seeding and planting. The newly constructed rain-pool functioned flawlessly (normal development of flora and fauna, including species unique to this habitat).
Most importantly, rehabilitation of disturbed habitats has a greater chance of being realized if implemented in the form of a nature community park. That is, a park aimed at nature conservation built with and for the community, which takes part in its planning, planting, seeding, maintenance and protection. This activity reinforces the public's awareness and concern for local biodiversity, strengthens the sense of belongingness and increases the probability of long-term sustainability.
This study offered a model implemented by the Tel Aviv municipality (among others) and boosted the ecological restoration of winter pond habitats within the urban area. These projects were developed with local pupils and are being analyzed and maintained frequently in order to keep track of the ecosystem and its viability.

**S-15 -Challenges of peatland restoration**

**S-15.1**

**Peat formation in rewetted fens: a palaeoecological perspective**
Hans Joosten, John Couwenberg, Dierk Michaelis, Almut Mrotzek
Institute of Botany and Landscape Ecology, GREIFSWALD, Germany

In Europe most fen peatlands have been severely degraded by land use. Drainage has turned the peatlands from carbon sinks into significant sources of greenhouse gases (GHG) and has made Central Europe – after Indonesia - the second largest hot-spot of peat GHG emissions worldwide. Peat formation is a precondition to re-install the central services provided by the fen ecosystem. Previous research on peatland carbon cycling has focused almost exclusively on rainwater-fed bogs with upward growing peatmoss (Sphagnum) as the prevailing mode of peat formation. In contrast, in groundwater-fed fens, roots and rhizomes of sedges and grasses grow into the older peat matrix to form 'displacement peat'.
This paper addresses peat formation in rewetted fens by way of fine-resolution palaeoecological approaches. Macro- and microfossil analysis shed light on pre-degradation peat composition, degradation during land use, mixture of old and new components after rewetting, and the start of renewed peat formation. The long-term perspectives of peat growth and carbon sequestration after rewetting of degraded fens will be discussed.

**S-15.2**

**Restoration of peatland biodiversity: target, indicator, or side effect**
Tatiana Minayeva[1], Igor Semenov[2], Andrey Sirin[3]
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[2]EthnoExpert, RIGA, Latvia
[3]Center for protection and restoration of peatland ecosystems RAS, MOSCOW, Russian Federation

Peatlands restoration is driven by very different incentives. The latest assessments of peatland restoration outcomes prove that often the restoration targets are contradicting and demand different restoration techniques. Biodiversity as restoration target is still considered as "charity" and "good will" in comparation with carbon and water - compatible with market values.
The overview of peatland restoration project outcomes shows that mostly the biodiversity parameters improve as "side effect". The increase of biodiversity as target of peatland restoration usually addresses flagship species or habitat types. Such projects are funded by regional initiatives (for example Life projects in Europe) and are considered as burden for the tax payer. The carbon and water focused peatland restoration projects are accompanied with changes in biodiversity anyhow as "side effect". More than that biodiversity is widely used as indicator for other ecosystem characteristics. One example is the GEST methodology based on designating certain

GHG emission factors to certain habitat types.
The peatland biodiversity itself provides a wide range of ecosystem services which are not adequately highlighted and evaluated. The presentation suggests methods to assess the benefits from the biodiversity restoration and gives examples of those assessments.

**S-15.3**

**Microbial communities in the soils in natural and restored fen peatlands - relevance for restoration**
Agata Klimkowska[1], Rudy Van Diggelen[1], Hanna Silvennoinen[2], Camiel Aggenbach[1], Willem-Jan Emsens[1], Erik Verbruggen[1], Wiktor Kotowski[3], Franziska Tanneberger[4], Elke Seeber[4], Hans Joosten[4], Lukasz Kozub[3]
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Role of microbial communities and microbial-driven soil processes is poorly understood in the context of fen restoration. However, an activity of microbial assemblies' determinates the carbon and nutrients cycling, methane production, and is, therefore, crucial for the outcomes of restoration. Various factors: climate, biochemistry, organic matter quality, hydrology, vegetation, or past management, all influence the microbial activity. In REPEAT project (REstoration and prognosis of PEAT formation in fens) together with partners from Poland, Germany, Belgium, and Norway, we explored the links between soil diversity and soil processes. We studied the functional characteristics (fingerprinting) of microbial communities in multiple sites across climate gradient from West Europe to North-East Poland and compared the natural and rewetted sites. The microbial characteristics varied strongly with soil depth, with larger and more variable response of the upper soil layer. We found a difference in response of fen peatland of West and East Europe, most likely related to the climatic conditions. Overall, the profiles of restored sites and natural, undrained fens were overlapping. Further we found some differences in utilization patterns of various carbon sources in degraded, drained sites and rewetted or natural sites, indicating a difference in 'diet preferences' of the microbial communities. This information was paralleled with the methane concentrations in the pore water, that indicates methane production potential of the sites. We found consistent patterns of methane concentration in restored and undrained Western European fens, with exception of Polis restored and natural fens that exhibited a generally differing pattern. This work presents the most comprehensive exploration of the microbial community in fens, so far. It underlines that, regarding the functional respones, the long-term rewetted sites become similar to natural sites. This gives a good prospect for restoring peat accumulation of such sites.

**S-15.4**

**Paludiculture: compromise or future?**
Marina Abramchuk[1], Wendelin Wichtmann[2], Jan Peters[1], Andreas Haberl[1], Hans Joosten[2]
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Utilisation of drained peatlands causes many problems for our environment and economy as a result of GHG emissions, nutrients release into surface and ground waters, soil degradation and subsidence, constant maintenance of direct drainage, etc. We have to solve these problems by rewetting the peatlands and installing water tables at around the soil surface. Where it makes sense to maintain production, paludiculture can be implemented. Paludiculture, the cultivation of biomass on wet and rewetted peatlands, is an innovative alternative to conventional drainage based peatland agriculture and forestry.
Here we present an overview of paludiculture options and experiences in Europe and the environmental and economic benefits and opportunities, as well as the challenges associated with paludiculture. Examples of peatlands rewetting and paludiculture application include harvesting biomass for nutrient recycling, growing peatmosses (*Sphagnum* spp.) for horticulture and cultivating Black Alder (*Alnus glutinosa*) for wood. Paludiculture can also provide renewable energy (biogas, bulk fuel), raw materials for durable and environmentally friendly construction and building materials (construction plates, insulation material), and feedstock for the synthesis of pharmaceuticals and cosmetics. Although various links in the paludiculture chains still need to be developed, optimised or adapted to specific site conditions (e.g. crop selection, infrastructure, products, machinery), many paludicultures can already compete with drainage-based agriculture.

**S-15.5**

**Social and economic preconditions and outcomes of peatland restoration**
Igor Semenov
EthnoExpert, RIGA, Latvia

Emerging market countries, including Russia, face a strong challenge regarding peatland rehabilitation. Many projects and developments, for example mining, peat extraction, farming and forestry, result in the land degradation. Returning the peatland in a given area to some degree of its former state, after industrial development has resulted

in its damage, is unpopular measure, which lacks social, economic and legal drivers.
At the same time disturbed peatlands are an actual worldwide ecological problem. Large areas of drained peatlands cause fires. Wildfires endanger local population's life and health, negatively affecting the overall climate change. The drained peatland area in Russia reaches 6 million hectares, and this figure is steadily growing every year. The project "Restoring peatlands in Russia", a project curated by Wetlands International, became one of the solutions focused on forming an integrated approach to managing the peatland conservation and restoration processes. "EthnoExpert" successfully applied Michael Succow Foundation's decision-making methodology for degraded peatlands in Russia.
The results of such studies inspire clear design solution identification, which reduces possible risks, ensures project's sustainability for a long time and maintains favourable social and environmental conditions for the population. From 2014 to 2018 "EthnoExpert" took part in more than ten peatland restoration projects in Moscow, Vladimir, Tver, Nizhny Novgorod, Ryazan, Kaluga and Kaliningrad regions.
Peatland restoration projects should make clear focus on sustainability with balanced approach in environmental, social and governance aspects. The key element for sustainable development is the extent of stakeholder involvement and interaction with them. Systemic dialogue is a crucial condition for the successful project implementation in modern conditions. All stages of the project must take into account stakeholder interests, informing them and managing their expectations. This significantly minimizes the risks of conflict of interest and decision-making crisis.

**S-15.6**

**GHG MONITORING FOR ASSESSING AND REPORTING ON EFFECTIVENESS OF PEATLAND RESTORATION**

Andrey Sirin[1], John Couwenberg[2], Hans Joosten[2], Gennady Suvorov[1], Maria Medvedeva[1], Aleksandr Maslov[1], Maxim Chistotin[3], Anastasiya Markina[1], Dmitry Makarov[1], Tamara Glukhova[1]
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Significant progress has been made over the last years with respect to estimating GHG emissions from degraded, rewetted and restored peatlands. The project "Restoring Peatlands in Russia – for fire prevention and climate change mitigation" financed under the International Climate Initiative (ICI) aims to show the effect of restoring/rewetting several ten thousand hectares of drained abandoned peatlands on climate change mitigation and adaptation. The project is linked to the governmental programme (2010-2013) to rewet more than 70 thousand hectares of fire vulnerable transformed peatlands, which Moscow Province started to implement after the severe fires in 2010. The project aims to assess the effectiveness of various large scale rewetting measures, to clarify whether such activities indeed reduce net-GHG emissions and whether available methods to evaluate GHG reduction are indeed consistent and comparable. Various remote sensing based methods were developed to map peatlands categories, to link these categories to emission factors and carbon stocks, to assess and monitor ecological conditions and fire hazard status, to identify priorities for restoration, and to test the effectiveness of rewetting for fire prevention and GHG emission reduction. Emission reductions from rewetting projects include reductions as a consequence of changes in a) peatland land/vegetation cover, b) area of ditches, and c) peat fire frequencies. The emission factors used were based on 2013 (2014) IPCC Wetlands Supplement, and tested against own chamber and Eddy Covariance measurements, and the vegetation-based GEST model. Methane emissions from ditches have been given special attention. Less carbon losses by reduced peat fires constitute major benefits for climate change mitigation. The scientific and practical findings of the project can inform other restoration projects, help improving methodologies for GHG inventories under UNFCCC and IPCC, and support integrating peatland restoration projects into cost-effective national climate change mitigation and adaptation programs.

**S-16 -Forest restoration at multiple scales: from species & microsites to habitats & landscapes, cont**

**S-16.1**

**Simulations of moose browsing in Sweden: effects on timber production and forest structure**

Miguel Montoro Girona[1], Anouschka Hof[1], Joakim Hjältén[1], Nathan DeJager[2]
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Moose are important socio-economical and ecological components of the boreal forest. They indeed represent a popular game species, induce spatial heterogeneity in forest ecosystems, create vital substrate to a wide range of organisms. High levels of browsing can have substantial negative economic and ecological effects on timber production and forest dynamics respectively. Based on the survey conducted by the Swedish Forest Agency during 2009–2013, moose browsing affected ~ 42% of the Scots pines, one of the main commercial tree species in Northern countries. Browsing influences the biodiversity and ecosystem services of boreal forests as it promotes changes on tree species composition, reduces food resources and nest site quality which will decrease habitat quality. The goal of this study is to evaluate the impact of different browsing intensities on Swedish forest ecosystems in terms of productivity and forest structure. Using LANDIS-II, we performed forest landscape

simulations and predicted the future forest dynamic and productivity for the next century under different moose density scenarios (no moose, moderate, high and very high). The average of forage availability does not experimented changes when browsing was higher than 66% of the current capacity of forests as the biomass accessible to moose (33 g/m$^2$) was removed. However, intermediate moose densities maintain 33% of forage available. Our simulations evidenced the high vulnerability of Scot pine to moose browsing. With high-level moose densities, the distribution area of Scots pine was reduced by 6% in only 40 years. On the contrary, browsing had no impact on biomass losses for Norway spruce which increased its distribution area in forest ecosystems. This study is the first step to provide insights into how to balance conflicting goals – timber production, hunting quotas and biodiversity conservation – under different moose and forest management scenarios in the context of climate change.

**S-16.2**

**Burning for browsing and biodiversity? The use of fire as a restoration tool**
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Sustainable forest management faces a number of urgent challenges, including land use conflicts between maintaining biodiversity for ecosystem functions, supporting conservation and maximizing forest production. Fire is an important disturbance in boreal forest but has been replaced with management in Fennoscandia, which have had negative effects on biodiversity. Nowadays burning is used as a tool in ecological restoration of boreal forest. Herbivory and fire are two disturbances that often co-occur but studies of their interactions are rare in forest ecosystems and almost absent in the boreal forests of Fennoscandia. The overarching aim with this project is to quantify the ecological long term (>10 years) effects of large scale wildfire and prescribed burnings on biodiversity, forage production and utilization of herbivores. The study is focused around three large natural fires in northern Sweden that burnt the same year and are located in landscapes with a range of management intensity. Prescribed burnings that burned the same year and unburned control stands are included as comparison. We show that fire has impact on the biodiversity of saproxylic assemblages for more than a decade and that fire under some conditions can be a driver of forage production for ungulates and is also a preferred habitat. The project is highly relevant for sustainable forest management because the potential synergistic effects that can be reached by combining the usefulness of a conservation measure (burning) for biodiversity conservation with damage prevention through alternative forage production.

**S-16.3**

**Restoring temperate deciduous woodland from recent succession on abandoned pastures**
Björn Nordén
Norsk Institutt for Naturforskning, OSLO, Norway

In north Europe, there is an urgent need for restoration of temperate deciduous woodland as this biome historically had a much larger distribution, and because restoration may present a preadaptive climate change strategy. Forest succession on abandoned agricultural land currently pose an opportunity for restoration. We studied the biodiversity in recent woodland at 13 sites in Norway and 13 sites in Sweden, the impact of habitats in the surrounding landscape, and of former land-use. Forest succession had not lead to an increase in woodland plant species after 60 years, probaly due to lack of nearby source populations and/or too shady conditions. However, fungal species richness on dead wood had increased irrespective of the nearby landscape and former land-use.
The recent woodlands are generally dense and mixed with Norway spruce (often spreading from plantations), which may limit biodiversity and important ecosystem services, and there may be a need for restoration interventions. To evaluate this, we study the biodiversity before and after restoration thinning. In one experimental plot and one control plot at each site, we surveyed forest structure, dead wood, vascular plants, insects, fungi on dead wood, number of oak seedlings, ash dieback, and powdery mildew on small oaks before thinning. 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 2019 to measure the short-term impact of the restoration thinning.
In addition, we study the economic potential of restoration thinning. Our data indicate that sales of wood from the initial thinning can compensate for the costs, but that the revenue may be limited and subsidies to the land-owners may be needed to stimulate activity. Currently however, the policy instruments to achieve this are not in place and need to be developed.

**S-16.4**

**Coast to mountain boreal landscape trajectory of intact forest fragmentation and loss**
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The boreal biome constitute a unique biodiversity and ecosystem services resource of which a large share is associated with natural and near-natural forest habitats. The Fennoscandian boreal forest have a long history of human impact. For northern Sweden, the most pre-dominant impact has occurred since the middle of the 1900s following the introduction of the modern forest management system with clearcutting, soil scarification and artificial planting. Although prominent impact occurred earlier at local scale, this management system has affected forest ecosystem and ecosystem processes at unprecedented levels and geographic scales. In this study we have analyzed the connectivity and structural characteristics of remaining forest patches on a 45,383 $km^2$ region covering the river Ångermanälven watershed with contributory watersheds, from the Gulf of Bothnia coast to the Scandinavian Mountain range. The data consist of a comprehensive satellite- and aerial photo-based chronosequence mapping where forest patches – 0.5 ha or larger and 20 m or wider – not subject to harvesting since 1960 have been identified. The study region was divided southeast to northwest into six 40km wide zones with lowest altitude 0m (zone 1), 46m (2), 148m (3), 207m (4), 252m (5) and 287m (6). The zones were dominated by forest land, ranging from 52% (6) to 84% (2). Our results show that the share remaining forest varies from 21-22% (2,3,4) to 67% (6) and that the number of single patches has increased between 2,4 (6) and 22,5 times (1). Large forest patches (≥1,000 ha) remains only in the foothills area (5,6), where also large-scale connected natural and near-natural forest components occur and form a contiguous intact forest belt. The impact on the coastal and inland areas are most severe with only scattered components remaining. The results are discussed with reference to functional connectivity, green infrastructure, conservation and forest landscape restoration.

**S-16.5**

**Restoring fire as a disturbance agent in boreal forests of Fennoscandia**
Grzegorz Mikusinski
Swedish University of Agricultural Sciences (SLU), RIDDARHYTTAN, Sweden

Fires are the most important type of natural disturbance in global boreal forests. In Fennoscandia, where boreal forests predominate, the fire has been a key disturbance agent until the middle of 19$^{th}$ century when effective methods to fight the spread of fire had been introduced. Some 150 years without fire has changed forest landscapes quite dramatically, and there is an increasing interest in restoration of ecosystems being subject to recurring fires. Simultaneously, it is predicted that number of natural forest fires in Fennoscandia will increase in future due to climate change. In this paper I discuss the ecological dimensions of prescribed burning used as a conservation tool in forests located in nature reserves and in managed forests and compare it with the situation observed after the largest natural forest fire that changed some 14 thousand hectares of forest in south-central Sweden in summer 2014. The restoration of this area consists of two approaches. The first one is salvage logging with planting of trees and the other approach relies on natural succession. I use the bird community to illustrate the differences between the effects of the two approaches in the initial years of succession. I conclude with discussion about prescribed fires as a tool to mimic the natural fire as main disturbance agent in boreal forests.

**S-16.6**

**What to improve? Systematizing forest restoration examples in South-Central Chile**
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Forest loss and degradation has determined a global concern for implementing effective restoration activities. Several countries have committed to restore vast amount of land, setting challenging goals for the next years, e.g., Inintiative 20×20 and the Bonn Challenge.Scaling restoration from local initiatives to larger areas is a global need. For example, Chile has committed to restore half a million ha by year 2035. About a 100 of different restoration initiatives have been identified in this country, but most of them are rather small (<1 ha). Beyond experiments, forest restoration should scale up if the goal is to become massive. In this study we analyzed ongoing research experiences, aiming at translating restoration ecology into practice. We first, (a) review some common characters that “successful” restoration experiences present in Chile. As example, (b) we analyze an ongoing research, dealing with fast-growing species monoculture plantations that are being converted into native forest. Furthermore, (c) we discuss someattributes of natural forest patches surrounded by exotic plantations, that may contribute to retaining plant biodiversity within adjacent exotic plantations.
Group planting schemes, the use of biological legacies and micro sites, improved native tree species production, and involving highly qualified workers are common aspects on “successful” restoration experiences in Chile. Wins and losses on the establishment of restoration initiatives are analyzed, exploring potential mechanisms that favor the establishment of native species in landscapes dominated by exotic forestry plantations. This information is relevant in order to learn from our experience before moving forward on larger attempts for forest restoration.

**W-6 Ecological restoration: Education, training, communication & opportunities for emplyability**

**W-6.1**

**International collaboration and virtual learning as tools to improve training and employability on Land Restoration**

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The Mediterranean region is vulnerable to land degradation, which affects important sectors of the economy (agriculture, fishing, tourism) and the supply of vital goods (water, food). Although “actions to restore ecosystems and biodiversity have significant potential to create new skills, jobs and business opportunities”, there is a considerable shortage of skilled workers in this field due to the lack of proper training.
The overall objective of the LANDCARE project is to improve training capacities in relation to Land Degradation and Rehabilitation, in order to fulfil the demands of an emerging labour market and contribute to the green economy. Land restoration is a field that requires training involving real study cases and hands-on experience. For this reason, the education path proposed in the project will combine short-term international mobility and innovative online learning (PLEs, SPOCs). Employability skills will be enhanced by means of personalized training and hands-on practices. To increase the scope of this strategy, the project reinforces interactions between students, educators, researchers, companies/agencies/NGOs and decision-makers.
The main activities proposed focus on training both staff (from academic and professional partners) and students (HEI, company staff and selected unemployed people). The teacher training will include a) intensive training in innovative online learning tools (PLE, SPOCs) and b) short-term joint events to reinforce training capacities in LD&R. The student training will be based on two types of blended mobility. The concepts of LD&R will be taught by means of an intensive study programme, involving mobility and flexible online training (PLE, SPOC). Practical experience and employment skills will be provided by means of an internship programme combined with solid online and personalised training on employment and entrepreneurship.

**W-6.2**

**Keys to success and challenges of the Master's Programme on Ecosystem Restoration taught in Madrid**

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Education, training and capacity building on ecological restoration is critical to meet the objectives of the CBD Action Plan for 2020, the 2030 Agenda for Sustainable Development, the EU Biodiversity Strategy and other major international initiatives. We present here an overview of existing Master’s and other graduate-level degree programmes on ecological restoration and the experience of the multi-institutional Master in Ecosystem Restoration (MER) that is jointly offered by four major public universities in Madrid (Spain) since 2006. We deem the results of the MER as successful in view of the strengths listed below and the various recognitions it has obtained. We explain the motivations that led us to create the MER and the factors that have allowed achieving the results obtained thus far. We identify some strengths and weaknesses observed to date and the major challenges for the near future. The major strengths are the multidisciplinary nature of the programme; expertise, professional reputation, and diversity of research fields of involved lecturers; high number and diversity of involved institutions in the programme; management autonomy of the programme budget; high motivation, diverse background and provenance countries of the students; high demand for enrolment; and a reasonable high rate of postgraduate employment in a period of economic crisis. Weaknesses include challenges in teaching students with different backgrounds, training of students in companies, coordination among universities, administrative support, and job opportunities for graduates. We operate on the principle that it is the students who “make” their MER. The MER programme has evolved as a network of knowledge and experience that links universities, lecturers, researchers, students, private and public companies, NGOs, and administration centres.

**W-6.3**

**Knowledge exchange in ecological restoration: dealing with complexity, uncertainty and plurality of values**

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The ecological restoration highlights the relationship of interdependence between the social and natural environment, developing a set of strategies aimed at the conservation of ecosystems and the management of the problems of socio-ecological systems. These are characterized by a high degree of complexity arising from the large number of elements and interactions involved, high levels of uncertainty, and the plurality of values and rationalities of the actors involved. From this perspective, the need to articulate interdisciplinary conceptual and methodological frameworks has been largely emphasized. The theory of the Risk Society, the perspective of post-normal science and the transdisciplinary approach provide conceptual and methodological elements which enrich our understanding of socio-ecological systems and their restoration. Here, we explore the opportunities for increasing the efficiency of knowledge exchange that may arise from the application of these approaches in ecological restoration. First, we will conceptualize each approach in the context of socio-ecological systems. Secondly, we will expose the set of methodological tools allowing the application these approaches. Thirdly, we will present practical examples of ecological restoration actions in which these elements were present, and the role they played in the course of each action, paying particular attention to the M.Sc. Program Management and Restoration of Natural Environments of the University of Alicante. Finally, we will discuss the main challenges arising from the complex network of relations between academia, private sector, government and society in the field of ecological restoration.

**W-6.4**

**Implementation of the in ecology, environment and sustainability course by using collaborative e-learning model.**

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Implementation of the in ecology, environment and sustainability course by using collaborative e-learning model. Technology, Education and Cultural Diversity, multi-disciplinary course in ecology, environment and sustainability is basically a model for trust building in online collaborative environments for students who are living, in different communities and culture, far away from each other. It is implemented by the educators of the participating groups, within small teams from diverse cultures, progressing from online communication (written, oral, video) to face-to-face interaction, in order to gradually build trust between participants that allow implementation of the training course by using collaborative learning model.
The model works through online collaboration via joint assignments over a period of at least one year. Team members get to know each other, develop mutual respect for implementing the goals of the course.

**W-7 Easy to use software for hydrological analyses. Useful for planning in hydrologically sensitive projects**

Chairs: Kaupo Kohv and Priit Voolaid

Workshop summary:
Workshop will provide practical GIS procedures for the beginners how to analyze LiDAR based digital elevation models for surface water movement and how to analyze potential changes in hydrology caused by planned restoration activities.

**S-17 -Converting bare soil into high consevational habitats: the importance of plant-soil interactions**

**S-17.1**

**Soil manipulation as an additional tool in ecosystem restoration: hot air or serious contribution?**

Rudy Van Diggelen
University of Antwerp, ANTWERPEN-WILRIJK, Belgium

All over Europe low-productive heathlands and semi-natural grasslands have decreased very fast in both surface and quality, e.g. the once common Nardus grasslands have become so rare that they are now a EU priority habitat. In economically less attractive regions such sites are normally abandoned, for instance those farther away from

urban areas where most consumers live or those in mountaineous regions with a less favourable climate. Developments in economiccally attractive regions are completely opposite: intensification and conversion to high productive but species-poor grasslands. In both situations the result is identical: typical species become rare or disappear completely. Many once common grassland plant species and butterflies are now on Red lists. Restoration of species-rich herbaceous vegetation has become a high priority in many countries. The present contribution aims to give an overview of techniques used and their effectiveness, with special emphasis on the role of soil manipulation. An important aspect of soil treatment is modifying nutrient availability to levels that are suitable to sustain proper functioning of the target ecosystem, in most cases this implies lowering soil fertility. However, many examples exist where –despite appearantly approriate soil manipulation- target communities do not develop at all or at least much worse as expected. An important reason may be that typical species are no longer present locally nor have sufficient dispersal capacity to reach a restored site. Recent ideas to explain such poor restoration response are that the soil community is not or ill-adapted to the target ecosystem and may supply nutrients via decomposition at a too high or too low rate. This view puts much emphasis on dispersal and establishment of the soil community as major determinants of the functioning of herbaceous communities. The present contribution will discuss to what degree there is evidence that such bottle-neck actually exists.

**S-17.2**

**Manipulation of soil buffering and biota addition: restoration of heathlands on former agricultural lands.**
Maaike Weijters[1], Roland Bobbink[1], Rudy Van Diggelen[2], Arrie Van der Bij[2]
[1]B-WARE research centre/Radboud University Nijmegen, NIJMEGEN, Netherlands
[2]University of Antwerp, ANTWERP, Belgium

To connect and reinforce existing dry and wet heathlands, agricultural areas are reclaimed and transformed into heathland. Therefore, the nutrient rich soil-layer is removed, and the natural hydrology restored. Even though abiotic conditions are suitable for the target vegetation after these restoration measured, vegetation development is not always as desired. Causes might be the dispersal limitation of plants or the relative too high soil buffering caused by liming in the agricultural past.
To maximise the restoration success, a large-scale (almost 20000 $m^2$) field experiment was started after topsoil removal in 2011. To better understand the role of soil pH on vegetation development, a pH gradient was created by adding elemental sulphur or lime. The constraint of limited dispersal of plants was tested by adding either fresh herbage (freshly cut hay) or sods (soil & standing vegetation) in a full factorial design with 3 replicates. The development of soil chemistry (nutrients & base cations) was measured for seven years as well as the development of the vegetation. Target was to restore a species-rich dry and wet heathland community.
In this presentation the results of this experiment will be presented. Based on the findings of this large-scale study, restoration techniques aiming on heathland restoration on former agricultural soils will be discussed.

**S-17.3**

**Interrelations of fungal and plant community dynamics in heathland restoration through soil transfer**
Dajana Radujkovic[1], Erik Verbruggen[1], Rudy Van Diggelen[2], Roland Bobbink[2], Maaike Weijters[2], Jim Harris[2], Mark Pawlett[2], Jan Frouz[2], Arrie Van der Bij[2]
[1]University of Antwerp, WILRIJK, Belgium

Heathlands in Western Europe have been in decline over the last century despite many efforts for preservation. An important cause has been large-scale conversion to agricultural lands, where often only patches of interspersed heathland vegetation remain. Previous efforts to restore agricultural land to a vegetation dominated by heather and other typical plants has proven to be difficult and results have been mixed.
Evidence suggests that apart from restoring physico-chemical conditions and ensuring plant propagule availability, also the soil microbial community may play a role in supporting heather establishment and maintainance. For instance, heather and agricultural grasslands have distinct types of mycorrhizal fungal associations, which affect plant-availability of nutrients from soil organic matter (SOM). Similarly, saprotrophic and pathogenic fungi may differentially affect heather compared to ruderal vegetation thereby stimulating the trajectory of vegetation development.
Here we studied a dry heathland restoration on former agricultural land, located within a larger matrix of primarily heather vegetation. After removal of topsoil and restoration of natural hydrology, in 2011 two factorial treatments with three levels were applied: three pH treatments (control, S addition (-pH), and $CaMg(CO_3)_2$ addition (+pH)) and three biotic treatment (control, mowed heather material added, and soil addition). We predicted that soil addition has a significant, and persistent effect on the fungal community through continuing interactions between fungi and plants. From soils in each of these treatments we followed the trajectory of fungal community development from 2011 until 2016 through a metabarcoding analysis of the ITS1 region of the fungal rRNA gene.
The results confirm our expectation that fungal communities are significantly different between the biotic treatments (control and different additions). Furthermore, this difference does not diminish through the years indicating a remarkably persistent effect of the initial fungal community state. These results may suggest potential fruitful avenues for future heathland restoration efforts.

**S-17.4**

**Soil fauna during various restoration practices**

Petra Benetkova[1], Ruurd Van Diggelen[2], Lubomir Tichy[2], Rojyar Moradi[2], Fabio Vincentini[2], Jaroslav Kukla[2], Jan Frouz[2]
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Ecosystem restoration plays a crucial role in fighting with consequences of climate change that we experience nowadays, but it is even more important for maintaining biological diversity for future generations. Achieving of functioning soil food web is as important as restoring plant community above it, however, driving processes belowground are different and more complex than aboveground.
We investigated soil biota and plants colonization in three different anthropologically disturbed soils. In the first case soil fauna was studied during various treatments (soil and plant material addition) used for heathland restoration in Netherlands; simillar design was used also in reforestation of former quarry in the Czech Republic and in the last case we examined impact of soil block introduction into bare substrate in post-mining spoil heaps also in the Czech Republic.
The results using all groups studied (microbial community, nematodes, mesofauna, macrofauna, plant communities) show that soil transplant and in some cases also transplant of plant material increased soil biota densities and made their communities more similar to target plants. However, this effects are typically restricted on places where soil or plant material has been applied. Inoculation effect even in close surroundings is typically much smaller.
We can conclude from all three projects that the soil addition is crucial for both above- and belowground ecosystem restoration and therefore for proper soil functioning. However, it seems that effectivity differs amongst soil fauna groups depending on body size, and also according to dilution of soil added into substrate and the substrate quality itself.

**S-17.5**

**Earthworms and ecosystem restoration - starting from zero.**

John Scullion
Aberystwyth University, ABERYSTWYTH, United Kingdom

Earthworms have a central role in the functioning of temperate ecosystems, with the exception of those based on very acid or wet soils. Their activities promote soil development, affecting physical, chemical and biotic characteristics. These activities affect root development, and thus the supply of water and nutrients to plants. Plant growth and inter-species competition in turn feedback as the amount and chemical composition of residues that form the substrate that supports earthworm communities.
Earthworm species vary in their life styles, support requirements and impacts on soil processes. Some are early colonisers of primitive ecosystems, are well adapted to the stress conditions typical of these ecosystems and are less demanding in relation to conditions needed to sustain their population. Others require more stable conditions, in terms of food supply and an ability to avoid stress. The latter have a greater impact on soil conditions.
This paper will explore interactions between ecosystem status and associated earthworm populations. Based on an understanding of these interactions, strategies for manipulating earthworm populations for ecosystem restoration will be discussed.

**S-17.6**

**Ecological restoration of acidified heathlands: fauna response to rock powder versus lime application**

Joost Vogels[1], Maaike Weijters[2], Roland Bobbink[2], Huig Bergsma[3], Henk Siepel[4]
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Soil acidification due to air pollution (ammonia, sulphur dioxide emissions) is a major problem in Dutch heathland ecosystems. This has resulted in biodiversity loss of bryophyte, lichen and vascular plant species richness. Recently, there is increasing evidence that soil acidification also leads to reduced invertebrate species richness and/or abundance. The causal links work either indirectly through reduced plant species richness, or more direct through reduced plant nutritional quality (increased plant N:P ratio) or hampered soil organic matter decomposition rates. Traditionally, the main restoration tool to counteract soil acidification in the Netherlands is the application of dolomite lime. Although proven effective in restoring soil buffer capacity and vascular plant species richness, invertebrate response is mixed, often even showing negative effects on characteristic heathland fauna species. These negative side-effects are thought to arise from shock effects of adding large quantities of quickly dissolving Ca and Mg to the soil, resulting in newly introduced nutrient imbalances at the micro-nutrient level and/or temporarily increased P-limited conditions as a result of lime application.
In order to reduce the risk of introducing new nutrient imbalances for fauna, as well as providing a working

restoration tool aimed at restoring habitat quality for all heathland biota, we tested an alternative restoration method using slow release soil buffering agents. These slow release agents consist of finely ground igneous rocks (rock powder) and release a broader spectrum of cations and micro-nutrients to the soil via mineral weathering. In a number of field trials in Dutch heathlands, we investigated and contrasted the faunal response to addition of several slow-release agents with both the original control situation as well as traditional liming. In this oral presentation we present the first promising results regarding fauna response after three years of experimental application.

**S-18 -Trait-based ecosystem engineering-using plant traits in recovery of ecosystem functions & services, cont.**

**S-18.1**

**Detection of changes in assembly rules during spontaneous grassland recovery**
Anikó Csecserits, Melinda Halassy, Barbara Lhotsky, Tamás Rédei, László Somay, Zoltán Botta-Dukát
MTA Centre for Ecological Research, VÁCRÁTÓT, Hungary

Detailed knowledge on the presence and changes of trait-based assembly rules in spontaneous succession can help planning and evaluating active restoration interventions in similar environments. Therefore, we studied the changes of trait composition and assembly rules in the secondary succession of old-fields in order to describe successional pathways. We expect that non-random patterns are present in succession, and these patterns show significant changes from convergence to divergence.
We conducted our study on abandoned agricultural fields in the forest-steppe zone of Hungary, on sand soil, with Pannonic sand steppes as target vegetation.
Community trait composition and trait-based assembly rules were assessed based on 40 permanent vegetation plots on old-fields resampled in 2000, 2008, 2010, and 2015. The dispersion of eleven traits was compared with a null-model and the effect of time since abandonment on the departure from random expectation was tested with linear mixed effect models.
No changes were found in the dispersion of two traits: seed weight and pollination type showed divergent pattern for the whole time. In case of three traits there were differences only among the studied years, which suggest fluctuation in the dominant process. There were significant changes with time in case of six traits. In case of seed bank type, dispersal type, flowering start and leaf dry matter content the changes followed the expectation: from convergence to divergence through random pattern, while in case of specific leaf area and life form the direction of changes were opposite.
Our results show that environmental filtering (causing convergence) and limiting similarity (causing divergence) act together, but through different traits. Assembly rules change during succession: at the start of the succession environment filtering is important and processes causing divergence became important later. However, some traits connected to regeneration are already divergent at the beginning of succession.

**S-18.2**

**Succession in sand grassland: trait-based view of spontaneous grassland recovery**
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There are several contrasting views of species assembly and ecological succession in the literature. Neutral theory of species assembly suggest that species assembly is a stochastic process and it is governed by dispersal processes and stochastic fluctuations in established populations. Another approach suggests that community assembly is determined by functional trait filtering governed by more or less predictable abiotic and biotic filtering processes selecting species from the available local species pool. We analysed functional diversity patterns using vegetative and regenerative traits in four replicates (sites) using 20 permanent plots (4m$^2$ each) during the first 12 years of secondary succession after heavy goose grazing in a sand area in Hungary. We addressed the following hypotheses using trait-based analyses: (i) At the beginning of succession we expected high fluctuations in the trait values. (ii) Various temporal patterns are expected in functional diversity of regenerative and vegetative traits. Our findings suggest that the first few years' vegetation development can be explained by the trait neutral theory of vegetation development. This was diminished later on, and an effect of filtering was detected. There were convergent change of some traits like clonal spreading, plant height, leaf area, terminal velocity, or pollination types in sites with similar vertical but different topographical position. Our findings weekly supported the second hypothesis, while there were some distinct patterns found for the functional richness of vegetative and regenerative traits. For functional divergence and evenness no clear distinctive pattern was detected. For both vegetative and regenerative trait groups an overall increase in functional divergence was detected. The increase in functional divergence usually considered as a signal of increased niche differentiation and increased rate of competition.

**S-18.3**

**How objectively do we interpret plant traits?**

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We present the development of an applied ecological support system for landscape greening, wherein corridors are widely advertised landscape features. The expected ecological functionality of dispersal enhancing step-stone habitats in fragmented landscape seems to have limited efficiency. We analysed trait distribution signature within the group of ancient forest plant species to pinpoint main ecological filters between forest and corridor and by that to improve guide lines on the biodiversity supporting wooded corridors. As assessment methods for that task greatly vary in quantitative quality and interpretation objectivity, we propose a methodological development in which are combined the extraction of the trend of trait change and comparison to the reference level formed by species with successful occupancy in corridors.
We show that objective methodologies for the evaluation of ecological filtering should include multiple functionally analogous traits, various analytical indices, and contrasting references. In forest plants from forest to corridor, establishment associated traits adjustment towards a common optimum with reference groups, while many dispersal traits showed divergence from both or at least one reference level. Latter indicates the ambiguity of interpretation of optimal dispersal adaptations. The filtering of some traits was indicated only by the reduction of variability.
The immigration of forest-restricted plants in corridors is limited by a few specific filters of dispersal and establishment. Low habitat quality is the main reason for the inefficient ecological functionality of wooded corridors. However, a single structure for quality optimisation cannot be suggested, as forest dwelling species have a great range of evolutionary adaptations. Only a corridor with the mixture of micro-sites can maximise the biodiversity supporting function, incorporating zones with tree created shade-stress for understorey, and sites with modest ground disturbances suppressing competition between herbs, and having structures facilitating visits by seed dispersal insects, mammals and birds from forest.

**S-18.4**

**Plant functional trait response to climate in Mediterranean drylands: contribution to restoration and combat desertification**

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Mediterranean drylands are particularly vulnerable to climate change. Predicted scenarios of increased aridity and changes in precipitation patterns may worsen water limitations which, in interaction with anthropogenic activities, may increase desertification. This is likely to result in decreased biological productivity, hampering ecosystems' functioning, and the delivery of ecosystem services. Hence, it is crucial to anticipate the consequences of climate change for dryland ecosystems, in order to improve land management strategies and restoration tools to combat desertification. Functional traits determine species' responses to environment, and their influence on ecosystem processes, thus providing a mechanistic tool to monitor ecosystems' response to climate. To understand potential impacts of climate change on Mediterranean drylands, we modelled the response of plant functional traits to climate in Holm-oak woodlands, using a spatial climatic gradient to predict changes over time. We identified nine plant traits responding to aridity along space, and validated that response over time. Increasing aridity was associated to a lower functional diversity for most traits. Inter-annual climatic fluctuations greatly affected functional trait community metrics, and functional diversity showed a similar response in space and over time to climatic limitations. Multi-trait functional diversity decreased non-linearly with aridity and responded in a more predictable way to aridity than species diversity. Thus, it can be used as an indicator to map areas at risk of desertification. Finally, we provide a comprehensive overview of the current restoration practice in Mediterranean drylands, showing that trait-based ecology is still poorly used in practice, particularly in restoration monitoring, where it could be a useful indicator of ecosystems' functional recovery. Our findings contribute to a better prediction of climate change effects on Mediterranean drylands, and to optimize land management and restoration strategies to mitigate land degradation in these areas.
Acknowledgements: This research was funded by FCT-MEC through project PTDC/AAG-GLO/0045/2014

**S-18.5**

**Ability of plant species to colonize human-disturbed habitats: effect of functional traits**

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In mild climate of temperate Europe spontaneous succession can be an effective tool for restoration of natural communities. In order to understand processes governing the succession we analyzed ability of plant species to colonize human-disturbed habitats. Based on presence of species in extensive dataset of dated successional series (in total over 2800 vegetation relevés sampled within the area of the Czech Republic, Central Europe), we quantified plant colonization ability in two ways: as plant colonization potential, which is corrected for the mass effect (species frequency in the landscape acquired from Czech National Phytosociological Database), and as colonization success, which is solely based on species frequency in disturbed habitats. We than correlated both indexes with

plant functional traits (excerpted from available databases) using regression trees.
The highest values of colonization potential (corrected for the mass effect) had woody species followed by small statured plants with low terminal velocity of seeds (i.e. easily dispersible by wind). This was despite tall species had otherwise high dispersal potential. The highest effect colonization success (based on realized frequency in disturbed habitats) had plant height. Tall species (including trees) had generally high colonization success. Small statured species compensated for it either by high capacity for clonal lateral spread or by low terminal velocity of seeds.
This implies that species developed multiple strategies to colonize the available habitats. Poor ability in one aspect of colonization can be compensated by good performances in other aspects. To a priori predict successful colonizers of disturbed habitat just by their traits is therefore difficult, which stress importance of in-situ explorations after the disturbance. This should be considered in restoration programs.

## O-12-Restoration strategies

### O-12.1

**ORBA - a new approach to predict time to recovery in restoration ecology**

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Species composition is a vital attribute of any ecosystem, and ecological restoration often has the 'natural' species composition as its target. In many restorations, the recovery of the species composition may take decades or even centuries, and therefore methods for predicting the time to recovery would be invaluable for the restoration science. We do however lack adequate methods.
We present a new, ordination regression-based approach (ORBA) for predicting time to recovery that allows both linear and asymptotic (logarithmic) relationships of compositional change with time. The approach uses ordination to obtain distances between restored plots and reference plots along a successional gradient, followed by a regression model that uses these distances to predict time to recovery. We demonstrate the approach using data from an experimental disturbance study from a boreal old-growth forest. We use data from the first nine years after disturbance to develop models, and the subsequent nine years for validation of the models.
Rates of compositional recovery followed the general pattern of decrease with time since disturbance. Accordingly, predictions from linear models were too optimistic about the time to recovery whereas the asymptotic models provided more precise predictions.
Our results demonstrate that the new approach opens for reliable prediction of recovery rates and time to recovery. Moreover, it allows us to assess whether recovery proceeds in the desired direction and to quantitatively compare restoration speed, and hence effectiveness, between alternative management options.

### O-12.2

**Long-term recovery of Mediterranean forests depends on restoration strategy and forest type**

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Forest extent is increasing in Northern Hemisphere due to active and passive restoration of old agricultural fields. Despite the large extension of restored forests, the success of both contrasting restoration strategies has never been evaluated over time in the Mediterranean region. We assessed how restoration strategy determines the recovery of forest structure, diversity, functional composition, dynamics, and multifunctionality along an 80-years chronosequence in four potential forest types either pine- or oak-dominated. We used the Spanish Forest Inventory data in Madrid region to characterize forests, and old aerial photos and land use maps to estimate forest age and restoration strategy. We assigned multiple references to each restored plot and calculated the response ratios of 11 forest attributes and functions, and a multifunctionality index based in eight functions. Eight of the 11 attributes and functions were more similar to references in secondary than in planted forests in potential oak forests. Only three attributes were different between secondary and planted forests in potential pine forests. Overall, the speed of recovery of forest attributes and functions did not depend on the restoration strategy, but there were some exceptions (e.g. tree biomass). Multifunctionality was higher and increased more rapidly in planted than in secondary forests in potential Mediterranean oak forests but it was similar for both restoration strategies in other potential forest types. The effect of restoration strategy in multifunctionality did not depend on abiotic constraints or the surrounding forest. Our results demonstrate that both active and passive restoration can be successful strategies depending on the restoration aim and the forest type. Overall, passive restoration is effective at creating forests with functions similar to reference forests, but active restoration can maximize and accelerate the recovery of functions such as biomass accumulation and multifunctionality in potential Mediterranean oak forests.

**O-12.3**

**LIFE LAGOON REFRESH. Ecological restoration in Venice Lagoon (Italy): concrete actions supported by numerical modelling**

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The LIFE LAGOON REFRESH project, started on September 2017, foresees the restoration of favourable conservation status of habitat 1150* (Coastal lagoons), in the northern Venice Lagoon (SCI IT3250031), and the recreation of favourable habitats for faunal species of community interest.
The project actions involve: diversion of a freshwater flow from the Sile river into the lagoon (necessary for the recreation of typical salt gradient of buffer areas); restoration of intertidal morphology through structures properly arranged to slow down the freshwater dispersion and to favour reed development; planting of *Phragmites australis* to accelerate the development of the reedbeds; transplantation of small dumps of seagrass species, suitable to accelerate the recolonization by aquatic plants of low-salinity environments; establishment of a protected zone of 70 ha controlling hunting and fishing pressure.
The project aims to exploit the ecosystem services related to recreation of a typical estuarine system to: counteract the depletion of lagoon bottom and fish communities; reduce eutrophication through reedbed phytoremediation function, favouring the presence of sensitive species and high ecological value aquatic plants; improve conservation status of bird species, including species from Annex I of the Birds Directive; increase the presence of fish species (Annex II of the Habitats Directive).
The restoration of salinity gradients will also contribute to increase biodiversity in the Natura 2000 network site, and to help achieving targets defined by the 2020 Biodiversity Strategy.
Numerical modelling was used as a supporting tool to investigate the circulation pattern and to define the most suitable project configuration. In particular, two- and three-dimensional hydrodynamic models were used to optimize the freshwater flow and the morphological configuration, in terms of salinity diffusion and hydraulic effects.
The effect of diversion on saline wedge intrusion on Sile river was also assessed. Details of setup, calibration and results of numerical modelling will be presented.

**O-12.4**

**Conservation cultures, refugee habitats, and the comparative approach: Restoration in the NE Atlantic region**

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Countries often vary in ‘conservation culture’, significantly affecting both what is considered desirable, and what is considered possible, in ecological restoration. Differing research traditions can and do reach contradictory conclusions.
In this presentation, I examine the example of the oceanic uplands of the NE Atlantic seaboard. Despite strong similarities in climate, geology, landforms, and landscape histories, the countries of this region have long had significantly differing conservation cultures. Britain and Ireland operate within EU structures and an ‘insular tradition’; while Norway and Iceland (with some significant variations) share a common Nordic approach. Until recently there has been surprisingly little effective contact between these ‘spheres’, to the degree that even quite basic features of species habitat requirements and of ecosystem function are often described differently. Habitat classification differs significantly, and this strongly affects practice. Contradictions in what is ‘known’ are frequent. In addition, different cultures, as expressed in regulation and regulatory practice, affect what can be achieved in ecological restoration.
In this presentation, I describe a number of examples from the region and argue that both the theory and practice of ecological restoration and of conservation management generally, would be significantly enhanced through comparative studies and the formation of a single ‘information space’ of researchers and practitioners. While what is thought desirable can legitimately vary, restoration practice would be improved by the better understanding of what is natural, what is feasible, and of effective practical techniques, that a common sphere of research and practice would provide. The application to other regions, and on larger geographic scales, is considered.

**O-12.5**

**Restoration of grasslands and related sustainability - how to deal with Agri-environmental policy?**

Klara Camska
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Restoration of valuable grasslands, especially in NATURA 2000 sites, is a substantial issue of nature conservation in the Czech Republic. Non-ploughed, species-rich grassland habitats are important as species-pools, for climate

mitigation, soil protection and traditional landscape mosaic maintenance (culture heritage). One of main reasons for grassland restoration is their degradation caused by abandonment of regular management in the decades after World War II., related to changes of land ownership due to political events, socio-economic changes in agriculture and rural community, etc. Especially mountain grasslands and grasslands in warm and dry regions with low biomass yield were threatened and therefore became subject of restoration projects. Restoration consisted usually on elimination of shrubs and intensive cutting or grazing in the first years, sometimes with additional fertilising, soil surface removal or water regime restoration and it used to be supported fully by public funds.
There are two main financial sources for restoration: EU Program LIFE and Operational Programme Environment. Several finished and on-going Czech conservation projects focused on restoration of non-forested HNV areas and sustainability of restored natural values was an obligatory part of the projects supported. The problem is that the causes of grassland degradation persist partly during and after the end of the project. The paper deals with different ways of fulfilling the sustainability of the projects and analyses existing barriers and missing connecting elements between two politic tools. Crucial issue is continual public support of extensive grassland measures, flexibility of the rules and support of socio-economic changes, like the involvement of private capital and civic activities.

**O-12.6**

**Multifunctional scoring of plant species to support decision-making for restoration of mining soils**
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Mine restoration programs are usually based on conventional rehabilitation techniques (e.g. waste removal, on-site sealing, dam building, soil amendments). These methods are often expensive and either difficult to apply when physical risks and/or environmental restrictions exist. These limitations have encouraged the use of plants for stabilization of mine tailings, thus promoting the ecological integration of mining structures within their surrounding landscape matrix.
Here, we use a study system shaped by seven Mediterranean metalliferous mine tailings that impose severe abiotic stress conditions (high salinity, heavy metal concentration and aridity, and low fertility) to detect plant species that work as ecosystem engineers able to promote multiple ecosystem functions. We specifically quantify the effects that different local plant species exert on 17 variables related with the ability to create multispecific plant patches, promote soil fertility, trigger organic matter decomposition and nutrient cycling, and soften abiotic stress in these extremely degraded ecosystems. We also identify the main functional traits underlying the plant's contribution to the rehabilitation of ecosystem functions.
As a result, we quantitatively score and rank thirteen plant species according to their multifunctional ability to improve ecosystem functions. Plant species with higher longevities and larger life-forms contribute the most to the promotion of ecosystem functions. Plants with C4 metabolism and lower root intensivity and depth:laterality ratios, as well as leaves with lower carbon:nitrogen ratios promote a faster recovery of ecosystem functions.
Finally, we use a practical case of a recently executed mine restoration project to show how multifunctional scoring can be applied in decision-making. This project turns a conventional mine soil rehabilitation design that focused on pollutant sealing into a habitat restoration program that seeks the promotion of multiple ecosystem services beyond the survival of planted species. This approach can help guarantee the long-term self-sustainability of restored sites.

**O-13-Ecosystem recovery & ecosystem services**

**O-13.1**

**Learning from the past - The relationships between tephra and vegetation**
Sigrún Dögg Eddudóttir, Egill Erlendsson, Guðrún Gísladóttir
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Volcanic eruptions can cause changes in vegetation and environment. The reactions of Icelandic ecosystems to volcanism, in particular thick tephra deposits, are poorly understood. Similarly, the potential for different vegetation communities to hinder the redistribution of tephra after initial deposition is not well known. Acquiring knowledge about long- and short-term impacts of tephra upon vegetation and environment is difficult, even with modern monitoring. Using the methods of paleoecology, the study of past events and environmental processes, it is possible to examine how tephra deposition has affected ecosystems in the past and make predictions of the effects of tephra fall in the future.
By studying past ecological changes it is possible to examine the effects of tephra layers deposited under different climate regimes, as well as tephra deposits of varying thickness and chemistry. The Hekla 4 tephra (4,200 cal. yr BP) is one of the most spatially extensive and voluminous Icelandic Holocene tephra layers. Paleoecological studies of lake sediments from northwest Iceland demonstrate the effects of this tephra on different vegetation communities. The tephra is observed to have buried the understorey vegetation of lowland woodlands whereas birch trees were more resilient. In contrast, open woodland on the highland margin gave way to dwarf shrub heath, a more resilient vegetation community, in response to the tephra fall and a cooling climate. Today ~42% of Iceland is classified as desert, a surface that cannot prevent wind erosion of tephra. Tephra fall comparable to Hekla 4 could therefore lead to periods of increased dust storms and poor air quality. This highlights the importance of re-establishing a multi-

layered, tall vegetation cover in Iceland. Greater vegetation cover could stabilise tephra deposits and hinder tephra redistribution more effectively. This study shows that the native birch woodland and dwarf shrub heath communities are well suited to such circumstances.

**O-13.2**

**Ecosystem development on Hekla volcano lava fields**

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Volcanic environments showcase a wide range of disturbances, including lava emplacement and tephra deposition. Volcanic deposits in cold regions feature a stressful environment for plants during primary succession. The development of high resilience ecosystems is therefore important to buffer the impact of tephra deposition. The extents and ages of the historical lava fields produced by Hekla volcano have recently been evaluated and yield an 860-year long lava chronosequence. This provides an ideal setting for studying the development of plant communities and soil cover over time. We investigate how environmental factors affect the development and how much time is needed for a resilient ecosystem to develop. Vegetation and soil measurements were conducted in all the historical lava fields, reflecting the diverse vegetation communities on the lavas and the environmental gradients driving the ecological succession. Multivariate analyses were used to identify patterns in the vegetation and different stages of succession. Four successional stages were identified. 1) initial colonization and coalescence of *Racomitrium lanuginosum* and *Stereocaulon* spp.; 2) secondary colonization and *R. lanuginosum* dominance; 3) vascular plant encroachment with dwarf- and taller shrubs. These stages indicate increased resilience. The fourth stage represents sites of high environmental stress within the highland region and/or retrogression by tephra deposition. *R. lanuginosum* rapidly becomes dominant on the young lava fields (<70 years) forming thick moss mats that still dominate on 700-year-old lavas in the lowlands. Tephra deposition is an important environmental driver for the succession to overcome the moss dominated stage. Moderately thick tephra deposits can facilitate the establishment of vascular plants causing the succession to progress into a more resilient plant community. However, relatively deep tephra deposits can erode the plant cover and cause retrogression. Shrub based plant communities are important to buffer the impact of tephra deposition in the Hekla region to maintain ecological stability.

**O-13.3**

**What should we plant to maximise the supply of multiple ecosystem services in the long-term?**

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The delivery of many ecosystem services that people rely on for their well-being is declining world-wide. This decline is likely to continue in the light of multiple global changes. Ecological restoration is increasingly touted as being a viable strategy to assist ecosystems in a way that improves their long-term supply of ecosystem services and makes them resilient to future threats, especially in biodiversity hotspots such as Mediterranean-type ecosystems. However, successful realisation of such a strategy requires a fundamental understanding of the link between ecosystem composition, related ecosystem functions and services, and influencing environmental factors. Measurable plant traits (e.g. height, specific leaf area, seed mass) have been recognised as such a link. Until now, however, trait-based research that addresses trade-offs among multiple services under the impact of multiple environmental factors to reliably support restoration in Mediterranean-type ecosystems is missing.
In our study, we started closing this gap by integrating empirical research and process-based simulation modelling approaches. We developed an eco-hydrological simulation model complementing an ongoing large-scale restoration project in Western Australia. This spatially-explicit model explicitly links vegetation composition (consisting of individual plant functional types described by traits), ecosystem functions, and the provision of ecosystem services. For a given vegetation composition and other properties of the ecosystem (in terms of soil and climatic conditions) processes for vegetation, nutrient and water dynamics are calculated and the delivery of ecosystem services are quantified. In a full factorial design of different plant trait compositions and influencing environmental factors, trade-offs among services could be assessed, and the resilience of the ecosystem towards multiple factors of global change were tested. In particular, we found assemblages of plant traits that minimise trade-offs among ecosystem services under global change. These findings will aid in improving restoration towards the resilient long-term supply of multiple ecosystem services in Mediterranean-type ecosystems.

**O-13.4**

**Landscape complexity moderates the efficiency of local management for restoring pollinator assemblages in olive groves**

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Agricultural intensification is a major driver of biodiversity (BD) and ecosystem services (ES) loss. One of the current challenges for scientists is to understand how to manage/restore agroecosystems in a sustainable and cost-effective way. This is especially important in the context of dry Mediterranean croplands, which are severely threatened by climate change. The Landscape Moderation Hypothesis of Biodiversity (LMHB) predicts better outcomes for BD and ES when local restoration actions or shift to agri-environmental management (AES) occur in a field embedded in an intermediate complex landscape.
We focused on pollinators to test the LMHB at regional level in Mediterranean olive groves, one of the most important non-annual crop of Europe. We used 208 solitary bee nest traps to measure colonization rates (CR) and infer pollinator abundance in 40 paired olive fields (extensively versus intensively-managed herbaceous cover) in 20 localities selected along a landscape complexity gradient. Additionally, we conducted pollinator censuses near (<200m) 30 randomly selected bee nests, to ascertain that CR was representative of pollinator abundance and function. General linear mixed models were fitted and the best models selected (according to AICc) to explain how solitary bees' CR varied with local management and how landscape complexity influenced this relationship. We also analyzed differences in CR between organic and non-organic management.
Our results showed that:
1) Organic-managed fields had higher CR regardless landscape complexity.
2) Differences in CR due to local management peak at intermediate landscapes, with fields with extensive management rendering much higher CR.
3) There was a highly significant correlation between bee-nest CR and flower visitation rates in censuses, which suggests that CR is a good estimator of pollinator abundance and function.
In conclusion, cost-effective investment in restoration aimed to recuperate pollinator BD and ES in these agroecosystems (i.e. AES) should target fields located in landscapes of intermediate complexity.

**O-13.5**

**Waste rock improvement with Rameal Chipped Wood for natural afforestation of a canadian mine site.**
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During the revegetation step at mine closure, one of the main constraints the seedlings support during their establishment on mine wastes is the lack of favorable microsites. The germination of the seedlings is affected by microclimatic conditions at the substratum surface, in particular temperature and moisture variations. The ramial chipped wood (RCW) could be an interesting material to create favorable microclimatic conditions for seed germination on mine wastes. It could improve the establishment of tree species, like jack pine (*Pinus banksiana*, Lamb.) and paper birch (*Betula papyrifera*, Marshall). This research project aims to understand whether or not this mulch increases the capacity for the seedlings to settle on mine waste rocks and which microclimatic conditions are involved. We installed an in situ experiment, during 5 months (May to September 2017), in North-Western Quebec, Canada. The experimental design was a randomized complete block design with four replications, put on a waste rock area (900m²) of a gold mine. Over the spread of mine waste rock, we tested four substratum treatments : sand (10 cm thickness), mulch of RCW (2cm) over sand (10cm), mulch of RCW (2cm) and mine waste rock (original substratum, control). On the site, we measured germination rates after sowing paper birch and jack pine seeds. Simultaneously, we measured soil moisture and temperature to investigate the mechanisms underlying the responses of tree seedlings. Germination rates of jack pine seedlings on waste rocks, RCW and RCW over sand were all significantly higher than the rates on sand despite a significantly greater soil moisture on sand compared to the three other treatments (ANOVA and Tukey post hoc tests). Using the Spearman correlation test, we found the soil moisture to be the main explanatory variable related to the response of both paper birch and jack pine seedlings.

**O-13.6**

**Skúmey in Glacier lagoon - Landscape and biosphere**
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The islet Skúmey (10.22 hcts) is located near the west shore of Jökulsárlón glacier lagoon, Southeast Iceland. It was subglacial until late 1970s, when Breiðamerkurjökull, an outlet glacier of Vatnajökul ice cap, retreated from this site, finally disappearing off the islet in the year 2000. It opened a unique opportunity to observe colonisation of species on a remote land, gradually becoming exposed. Primary ecological succession appeared concurrently as the glacier retreated, therefore the establishment of vegetation cover varies along the islet's terrain. The advances are greatest where it became primarily exposed and decline gradually towards the last ice-free area.

Within the study sites in 2017, the average cover of vascular plants was 2–24% and the cover of nonvascular plants zero to 27%. The bug fauna was investigated ; which species were present and which were dominant in the ecosystem. The main groups of bugs found were *Diptera, Arachnida, Coleoptera, Acari* and *Collembola.* Most species found were typical for the ecosystem present while some species were atypical for the habitats of such place.
The islet's bird popularity with the nesting of Barnacle Goose *(Branta leucopsis)* also affect its ecological succession.

The number of nests turned out to be 968. The islet is the largest single breeding area for Barnacle Goose in SE-Iceland. More than 4000 eggs were counted, resulting with an average of 4.2 eggs per nest. Additionally a Common Eider *(Somateria mollissima)*, Great Skua *(Stercorarius skua)*, Purple Sandpiper *(Calidris maritima)* and Common Ringed Plover *(Charadrius hiaticula)* breed on the islet.
Skúmey islet's unique environmental conditions make it an important subject within the field of ecological succession studies.

**S-19 -A more comprehensive restoration using nature-based and/or ecological engineering approaches**

**S-19.1**

**Using ecological engineering for sustainable ecosystem restoration?**
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The international politic elaborated in 2010 during the International Convention of Biological Diversity aims at restoring at least 15% of degraded ecosystems by 2020. However, active ecological restoration operations did not allow immediatly to retrieve all the desired reference ecosystem composition and functions. Uncertainty is also to be expected in dealing with natural recovery processes, also called passive or spontaneous restoration, which may lead up to the creation of 'novel ecosystems' after the end of degradation causes, generally supporting lower biodiversity and providing lower amounts of ecosystem services. Practitionners therefore currently hit againts a 'glass ceiling' - an average value of restoration success that they can not overcome - when they implement ecological restoration operations. However, this ceiling of glass could perhaps be crossed by the uses of restoration techniques pertaining more to the use of life itself than to non sustainable techniques of civil engineering. After defining nature-based solutions and ecological engineering, several examples will be presented in relation to the use of these different techniques from concrete operations realised in a Mediterranean steppic grassland of Southern France.

**S-19.2**

**Large-scale patterns in spontaneous restoration**
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We evaluated success or failure of spontaneous restoration at regional, country, and global scales. The regional and country scales concerned temperate central Europe, the global scale involved all world biomes. We predominantly considered primary successions in mining sites, and secondary successions in abandoned fields. At the regional scale, spontaneous restoration appeared to be successful in sand pits, stone quarries, and extracted peatlands, mostly approaching after several decades stages being close to the reference sites occurring in the surroundings. At the country scale (Czech Republic) all studied 19 chronosequences ran in their directions towards reference potential natural vegetation. Using extrapolation, it was estimated that primary successions reached the respective potential natural vegetation between 190 and 220 years, while secondary successions between 200 and 340 years. At the global scale, only 14% out of 93 chronosequences in abandoned fields, and 12% out of 73 chronosequences in mining sites appeared as totally unsuccessful to reach a target during the period of ca. 100 years. The "success" of succession differed among biomes and increased with latitude. It was concluded that spontaneous restoration was more effective then it had been expected and it could be more frequently used in restoration programs over the World.

**S-19.3**

**Natural processes and soil development in post mining sites, plants and soil biota engineering effect**
Jan Frouz
Charles University, PRAHA, Czech Republic

During ecosystem development, plants leave legacy in ecosystem, namely in soil, which affect future ecosystem changes. These effects of plants is happen via two major pathways: via interaction of plant roots and soil environment and via effect of plant litter on soil. Both of this interaction pathway include complex set of interaction, which act at various spatiotemporal scales from immediate release of nutrients, which may affect plant who stimulate the process to changes in microbial community, which may affect next generation of plant to formation of soil aggregates and whole soil profile, which may modify succession of plant community in long term. Soil biota play key role in these interactions this include interaction of microflora including mycorrhiza and other root symbionts pathogens but also whole soil microbial community but also interactions with sol fauna. This again include various set of interaction from herbivory to engineering effect on soil formation. In this contribution, we will briefly review these interactions on example of post-mining sites development, with particular focus on engineering effect pf plants

and soil fauna that lead to soil profile formation which shape long-term successional development.

**S-19.4**

**Ecosystem engineers: how Pedicularis palustris facilitates fen meadow restoration.**
Kris Decleer[1], Rudy Van Diggelen[2]
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'Ecosystem engineers' have a critical role in the structure and function of natural communities and need to be considered as focal species to enable successful conservation or restoration of ecosystems. Through introduction and/or managing a single species, an entire community can be influenced. In our study we show that *Pedicularis palustris*, an endangered hemiparasite in large parts of Europe, can act as an 'ecosystem engineer', speeding up the restoration of undrained fen-meadow ecosystems colonized by species-poor and resistant *Carex acuta* vegetation. The parasitic behavior of *Pedicularis palustris* on tall sedges significantly alters local plant diversity, biomass production and soil characteristics. Our experiments show that, under the right hydrological conditions and mowing management practice, several target species for nature conservation can benefit from the gaps it creates in above-ground *Carex acuta* vegetation and its dense below-ground root system. The more prominent presence of mosses and lower density of the topsoil stimulates the recovery of mesotrophic transition mire with active peat formation. Since this habitat type is specifically protected under the European Habitat Directive, (re)introduction of *Pedicularis palustris* in similar sites within its geographical distribution range in Europe may be a helpful tool to achieve the imposed obligations for appropriate management and restoration.

**S-19.5**

**Domestic livestock as ecosystems engineers: Possibilities and pitfalls - Linking case study and landscape approach**
Albin Blaschka, Thomas Guggenberger
AREC Raumberg-Gumpenstein, IRDNING-DONNERSBACHTAL, Austria

For large scale restoration of cultural landscapes consisting of low-productivity ecosystems, the use of livestock has turned out to be an effective tool for management and restoration.

Here, the combined lessons from several case studies dealing with high pasture management and restoration using livestock in the Austrian Alps are discussed. These lessons can be summarised best by five topics: People, scale, governance, "wicked problems" and local knowledge. Ecological Restoration has to consider working within a social-ecological ecosystem and to follow a landscape approach.

Browsing or grazing livestock has the potential to influence natural processes: Trampling, nutrient relocation and different behavioural patterns influence habitats directly, but livestock shapes the landscape also indirectly, as a distinct land-use pattern with its people, traditions and logistics. Using livestock, it is possible with low effort to keep or restore an open landscape, thus preserving such often endangered extensive ecosystems and habitats with a high diversity.

Working with livestock also brings constraints and responsibilities, leading to pitfalls: Often, the vegetation to change (e.g. working against shrub encroachment) has a reduced carrying capacity for livestock - Requirements for restoration and nutritional requirements of animals are opposing needs. This is one of several wicked problems which can arise, which has to be tackled already during the planning phase, with involvement of owners, clear priorities and transparent procedures/contingency plans.

On the social-ecological side, doing restoration work using livestock broadens the scope of agriculture into a stewardship for the landscape and connects restoration work with the local community and economy, interacting with other land uses, fostering a multifunctional landscape. For pursuing ecological goals using livestock, it is most of the time necessary to follow cultural goals. Done right, considering the five points mentioned, the benefit is a sustainable, low cost method for the restoration of open habitats.

**S-20 -Restoration & species introduction in urban areas**

**S-20.1**

**Restoration in urban areas - where are we and where do we want to get?**
Valentin Klaus
ETH Zürich, ZÜRICH, Switzerland

*Comment: first talk in the symposium, as it will also serve as the general introduction to the following talks*

Losing land due to urbanization clearly affects biodiversity and the delivery of ecosystem services. Between 2000 and 2012, the average area of land taken for the development of buildings and other artificial surfaces in the EU was estimated to be 926 $km^2$ per year. Thus, cities, industrial areas and infrastructure strongly expand on the cost of rural and natural landscapes, decreasing the area of habitats for native species. On the contrary, cities contain numerous green spaces, green roofs and brownfields, whichpotentially provide social, financial, recreational, and even environmental ecosystem services, including biodiversity conservation. Despite this ecological potential, the diversity of native plants in urban habitats is often quite low due to missing source populations and dispersal limitation. Poor (native) biodiversity of urban habitats not only hampers species conservation in cities, but it also restricts some important ecosystem services such as the aesthetic value, e.g. for recreation. Due to the specific urban setting, restoration strategies working in agricultural areas and rural landscapes cannot be directly transferred to cities. Thus, widening the scope of ecological restoration to urban (novel) ecosystems is one of the most important recent challenges for fundamental and applied restoration research, also because some urban habitats can clearly be seen as novel ecosystems, which lack a historical reference ecosystem. This talk focuses on urban grasslands to give an overview of the potentials of and restrictions to urban restoration projects. Different aspects, some more theoretical (Why to considers urban habitats?), some technical (How to introduce species in urban grasslands?) and some participatory (How to involve the city population?) will be addressed.

**S-20.2**

**Ecological restoration in cities: Do citizens' needs and biodiversity conservation meet?**
Lena Neuenkamp[1], Leonie Fischer[2], Jussi Lampinen[3], Maria Tuomi[3], Valentin H. Klaus[4]
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[4]ETH Zürich, ZÜRICH, Switzerland

Urbanization is one of the most severe threats to biodiversity, so why should we not use greenspaces in cities to counteract the biodiversity loss as much as possible? To date, many concepts and projects on how to improve the ecological quality of urban habitats have been developed. However, they rarely considered the use and the perception of urban greenspaces by city inhabitants but primarily focused on ecologically-oriented management schemes. Introducing ecologically-oriented management often changes the appearance of greenspaces. Therefore, to include city inhabitants, as the users of urban greenspaces, into urban restoration projects is highly relevant to increase public acceptance.
We performed a questionnaire survey asking city inhabitants about their use of urban grassland areas and their perception of an ecological management that may potentially change the usability of grassland areas. We focused on the acceptance of converting short-mown lawns to tall-growing near-natural grasslands. In semi-arid southern European cities, we also asked about ceasing the irrigation of grassland areas. Additionally, our study assessed whether the attitude towards near-natural urban grasslands changed when people knew about the potential benefits for biodiversity conservation. We collected data from 19 European cities with sample size N=2000.
Our results show that the majority of citizens appreciate urban greenspaces as valuable habitats for plants and animals and support reduced mowing frequency in urban grasslands as means for increasing their habitat quality and biodiversity. Regarding irrigation, southern European citizens widely rejected dry and rather “wild” looking areas, although these areas look very similar to native habitats in that ecoregion. In contrast, the overall acceptance to convert short lawns into non-irrigated, ecologically more valuable tall grassland areas was higher in southern than in northern cities. Outcomes of our study support integrative management decisions and point to different options of how to increase their acceptance among city inhabitants.

**S-20.3**

**Supporting regional biodiversity by roof greening with native plants - lessons from a 4-year experiment**
Roland Schröder[1], Kathrin Kiehl[2]
[1]Osnabrück University of Applied Sciences, OSNABRÜCK, Germany

Green roofs as elements of green infrastructure are known to provide valuable ecosystem functions for sustainable urban development. Conventional green roofs, however, have mostly been developed by species-poor plant mixtures containing non-native plant species (incl. cultivated varieties). Their potential for supporting local native biodiversity might be enlarged considerably by using native species of regional origin. Therefore, we tested the suitability of plant species from ancient acidic dry grasslands (Koelerio-Corynophoretea) in northwestern Germany in a 4-year outdoor experiment. In spring 2015 we introduced a seed mixture containing 25 vascular plant species with seed densities of $1g/m^2$, $2g/m^2$ and $1g/m^2$ plus raked material from original dry grasslands on experimental miniature roofs ($2m^2$) with 9 cm substrate layer thickness. Experimental units were managed (occasional watering) until 15 month after sowing. Overall, 88 % of the sown species established until 2016 with c. 70 % vascular plant species cover in sowing treatments and 60 % in the treatment with raked material. In 2016 and 2017 vegetation cover did not differ between the two sowing treatments while vegetation cover of the treatment with additional raked material was always significantly larger due to introduced moss and lichen species. Raked material increased target species richness by 20 species. Drought in late summer 2016 resulted in a strong decline of vascular plant species cover

below 10 % in sown plots. In the treatment with raked material the decline of vascular plants was less severe (22.3 % cover) due to the mitigating effect of mosses and lichens. Grasses were the most dominant plant functional group in 2016, but in 2017 legume cover increased. In this talk we will also present results of the fourth growing season (2018) which will show if vegetation is able to regenerate from a potentially developed soil seed bank.

**S-20.4**

**Is no green roof an island? Impact of the local and regional environment on diversity**
Jan Vanstockem, Ben Somers, Martin Hermy
KU Leuven, HEVERLEE, Belgium

Extensive green roofs (EGR) are novel ecosystems with an important role to play in the sustainability of our cities by providing a large range of ecosystem services which can improve urban environments. However, despite increasing scientific and commercial interests, several aspects of this form of urban green, such as their connectivity and practical problems such as 'weedy' species and gaps in the vegetation, have received limited attention. We therefore perform a large scale study on 129 EGR in Brussels and Flanders where we focus on (functional) plant diversity both in the vegetation and in the seed bank, as well as different connectivity measures. We expect that local characteristics (substrate depth, age) as well as regional characteristics (connectivity, land use types around roof) will impact EGR plant species (functional) diversity. Preliminary results reveal that on average 80 percent of the species richness on these EGR is made up of species that have spontaneously colonized the roof. Additionally, EGR species appear to be mostly anemochorous. Because the regional species influx appears to impact the EGR, we investigate this further by using a range of different connectivity measures and land cover classes in radii around the sampled EGR. By considering species as well as their traits, we are able to draw conclusions that can be applied to the broad context of EGR in temperate climates.

**S-20.5** *Kiel, Neuenkamp;Klaus*

**S-21 -Ecological restoration under complex socioenvironmental conditions: the Latin-America experience**

**S-21.1**

**THE USE OF HISTORICAL ECOLOGY TO UNDERSTAND A PATAGONIAN LANDSCAPE FOR PLANNING RESTORATION IN CHILE**
Arellano Eduardo[1], Zegers Gabriel[1], Ostlund Lars[2], Ginocchio Rosanna[1]
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[2]Swedish University of Agricultural sciences, UMEA, Sweden

The current landscapes in Southern Patagonian are the result of socioeconomic and ecological changes, intensified in the last 140 years. *Nothofagus* forests in the Southern Patagonia region of Chile are highly degraded because of clearing for human settlements since the early 1900s, extensive livestock breeding, and more recently the impact of coal mining operations. These legacy areas have remained as extensive meadows, showing limited forest recovery. Ecotonal zones between eastern semi-arid steppes and western *Nothofagus sp.* forests and their remaining biological evidences of pre-European landscape, are clear examples of these changes. Our objectives are to (1) determine the historical changes in land use and land cover and their relationships to the driving forces associated to changes in *Nothofagus sp.* forest ecosystems; (2) and describe the recent trends of *Nothofagus sp.* forest cover and their potential management implications over landscape planning. The study area comprises 2700 $Km^2$ in the Rio Verde rural district (52ºS – 71ºW), where historical records from the 19th century including scientific and military expeditions, regional archives and bibliography. Trends in forest cover were observed with spatiotemporal analysis of classified Landsat imagery and field sampling. Overall forest cover change showed an average 25% reduction since late 19th century to mid $20^{th}$ century, from a subsistence littoral forest indigenous use, to industrial forestry and livestock management. Changes in soil quality, wind speed, and radiation intensity have limited the establishment of Nothofagus pumilio seedlings. Therefore, active reforestation is needed to restore the forests. Our research contributes to the development of recommendations for the recovery of this type of forest and the implementation of an integrative restoration plan for highly disturbed ecosystems in Southern Patagonia.

**S-21.2**

**Landscape restoration in a Chilean biodiversity hotspot: planning a buffer strip and hedgerow network**
José M Rey Benayas[1], Adison Altamirano[2], Alejandro Miranda[3], Germán Catalán[3], Marco Prado[3], Fulgencio Lisón[3], James Bullock[4]
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The positive impact of natural or semi-natural linear vegetation elements for biodiversity and ecosystem services is well documented. However, guidance for large-scale restoration of such features is often lacking. Focussing on a Chilean biodiversity hostspot, this study develops a plan for a buffer strip and hedgerow network at the field, landscape, and catchment scale as a step towards cost-effective restoration. We present seven general guidelines for buffer strip and hedgerow restoration that stem from ecological principles, the scientific evidence, and our 10-year experience as practitioners, and tailor these to a case study in the Valdivian Rainforest Ecoregion. We assessed the landscape in terms of the existing woody vegetation elements, proposed a buffer strip and hedgerow network considering landscape spatial analysis, field surveys, prioritization criteria, and seedling availability in the region's nurseries, and estimated the budget for implementing the proposed network. Buffer strips and hedgerows comprised on average 5.1 and 20.9 m $ha^{-1}$, respectively. The forest remnants, tree plantations, and tree lines provided 20.4, 6.1 and 5.31 m $ha^{-1}$, respectively, of woody edges to the fields. Woody plant communities comprised 33 shrub and tree species, of which 13 (39.4%) were exotic. Mean species richness and mean density per 20x3-m plot were 1.74 ± 1.12 (SD) species and 6.13 ± 5.78 individuals, respectively. A total of 2,040 ha of buffer strips must be restored in the catchment by Chilean law. A relatively low proportion of fields, ranging between 14.5% and 31.3% in three representative agricultural landscapes, did not meet our target of 5% area of existing native woody vegetation elements. The average estimated cost of buffer strip plantings was USD 7,396 $ha^{-1}$ and of hedgerows ranged between USD 6,619 and USD 7,169 $ha^{-1}$. Financial incentives, education, and professional training of farmers are identified as key issues to implement the suggested restoration actions.

**S-21.3**

**Ecological restoration and the social construction of the territory**

Pilar Andrés[1], Roger Villalobos[2], Consuelo Bonfil[3]
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In Latin America and the Caribbean, where human demand for natural resources is the dominant driver of ecosystem degradation, ecological restoration success depends on the ability of restoration managers to bring together the contrasting visions of all significant actors. To paraphrase the promoters of the "model forests" initiative, an ecological restoration project is simultaneously a place (a degraded ecosystem), a partnership of a variety of actors (from local farmers to national policy-makers or international organizations), and a process towards sustainable restoration through dialogue, experimentation and innovation. In this framework, ecological restoration must be tackled through a truly participatory approach offering a solid ground for the development and execution of viable proposals.
In this work, we compared community-based ecological restoration cases from Colombia, Dominican Republic, Costa Rica, Mexico and Nicaragua with the aim to identify the main determinants of success or failure.
In all cases, long-lasting extensive cattle ranching had caused forest area reduction and fragmentation, extreme soil degradation and water shortage, with increasing risk of hard-core poverty and food insecurity. The most viable restoration option always was the implantation of agrosilvopastoral systems with high environmental value, derived from the smart combination of productive and protective uses.
Factors contributing to the success of the projects were: (a) restoration planning at the landscape scale, (b) income generation from early phases of the project, (c) priority to guaranteeing food security and access to water and basic resources, as a prerequisite to allocate land to protective use, (d) strong community institutions (social capital), (e) clear definition of actor's compromises, (f) co-construction of knowledge between all actors, (g) active involvement of local leaders and, (g) economic incentives integrated into rural development plans. Weak community cohesion and legal prohibitions (such as bans to extract forest products) were always counterproductive.

**S-21.4**

**Multiple benefits of mixing organic residues and mine tailings: cases in North and South America**

Rosanna Ginocchio[1], Eduardo C. Arellano[1], Mónica Gandarillas[2], Mike Van ham[3], Sally Brown[4]
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Mine closure regulations require proper physical and chemical stabilization of post-operative tailings storage facilities (TSFs). Stabilization of TSFs may be achieved by different technologies, ranging from chemical to physical and plant based ones. Our reseach has demonstrated that aided phytostabilization, an organic residue(s) and plant-based technology, is cost-effective and effectively reduce erosion protential, bring physical stability, assure chemical stability, and reduce environmental risks of metal(oid)s in post operative tailings. However, specific aided phytostabilization solutions have to be designed for each TSF as high specificity of climate, geochemistry, biogeography, land-use, availability of organic residues, and proximity to populated/productive centers, will vary across sites.
We have demonstrated that in addition to minimizing environmental risks of mine wastes and meeting (complying) regulatory requirements, aided phytostabilization bring multiple environmental benefits, without adding extra costs.

Specifically, it allows reestablishment of natural systems and restoration of ecosystem services (i.e. biodiversity, carbon sequestration in substrate, recreation/aesthetic value). Other advantages of this technology include beneficial use of other massively produced industrial/depurative residues that would otherwise be landfilled or improperly disposed of. Amendments applied to tailings speed-up soil formation and are critical to establishment of a plant cover. Integrating residuals from different sources also solves broader environmental problems with larger socio-environmental impacts. Good examples include the use of biosolids (sewage sludge), pig slurry digestates, and carbon-rich residues of either the fruit or forestry producing industry, among others, as tailings amendments. The efficacy of this approach has been demonstrated by research groups in Chile, Canadá, and USA. Finally, other more recently evaluated benefits are related to crop or tree cultivation on post-operative TSFs for non-edible plant-derived products. These products are mainly related to carbon sequestration and bioenergy production such as energy derived from seed oil and biomass.

**S-21.5**

**Ecological Restoration in Costa Rica: Contribution of the Ecological Restoration Network and Huella Verde Project**

Mery Ocampo, Wilmar Ovares, Héctor Brenes
Universidad Estatal a Distancia, SAN JOSE, Costa Rica

The *Huella Verde Project* and the Ecological Restoration Network are initiatives that have been working in Costa Rica since 2015 as means to promote ecological restoration and projects related to this topic. Contributions and agreements have been made with the Costa Rican Sports Institute, La Cangreja National Park and SINAC (National Conservation's Areas System), in order to support active and passive restoration processes in different parts of the country. In the urban context, an agreement has been established based on the study and monitoring of La Sabana Metropolitan Park, the main recreational park in the capital of "‹"‹the country, where exotic trees have been replaced by native vegetation. At the recently created La Cangreja National Park, experimental plots have been established with different treatments to enable didactic-learning and research, and to support highly degraded natural areas that need immediate intervention. Research has also been developed in coastal areas of Guanacaste, situated in the northwest of the country to study the adaptation of native coastal species to climate change, where these areas are being affected by sea level rise, in order to assess how to mitigate these changes. Some of the applied methodologies are taken from the Horizontes experimental station, where studies on the subject have taken place for more than 30 years. Alliances have been established, with the station for student training, application of methodologies and development of volunteering and research. In the last three decades, Costa Rica has been leading the research on ecological restoration in Central America; that is why it is so important to carry on the implementation of this kind of initiatives as part of the future environmental policies.

**O-14 - Planning & evaluation of restoration**

**O-14.1**

**Establishing a local reference system for the evaluation of the vegetation dynamics in restored systems.**

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Within the framework of operations of restoration, the definition of a reference ecosystem is an essential stage both for the definition of the objectives and for the evaluation of the operation. If this evaluation owes to be envisaged in a global way by integrating the various components of the ecosystem, the follow-up of the vegetation appears as the central element of this evaluation.
The implementation of vegetation relevés allows to follow the reestablishment of its structural and functional characteristics. These have to be compared with a reference in order to evaluate the restoration state of the ecosystem and the efficiency of the implemented measures.
Various approach can be use. A control site, considered as similar to the restored site can be chosen, comparison with data collected in the literature or available in database can be realised or a specifically established panel of relevés can be used.
In the framework of an experimentation network for wetland rehabilitation, several sites were submitted to rehabilitation operations aimed to re-establishing characteristic hydrological functioning and biodiversity. These sites were subjected to surveys concerning flora, soil, fauna and hydrology.
Parallelly, vegetation relevés were made in a set of close sites presenting similar characteristics in order to establish a a panel of reference relevés. The similarity between these relevés and those made in restored sites will allow to evaluate the restoration dynamics.
Thus, using multivariate analysis a "target ball" was constructed, integrating the local variation in considered wetland composition and indices allowing to place the restored vegetation and its dynamics, relatively to the reference panel,were proposed.
In this presentation we will present the establishment process of the local reference panel and its use as evaluation tool of the restoration of restored sites along the three first year after the restoration works.

**O-14.2**

**Monitoring change in ecological restoration: Species composition as indicators**
Margaret O'Connell, James Hallett
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Assessment of restoration projects is essential for adaptive management and for justifying their costs, but comprehensive monitoring and evaluation are not always incorporated into projects. We developed a cost-effective monitoring program for lands managed by 5 Native American tribes in northeastern Washington and adjacent Idaho, USA. Key ecological objectives of restoration efforts are that the restored area (1) has an assemblage of species characteristic of a reference ecosystem that provides appropriate community structure, and (2) consists largely of indigenous species. We established 24 reference points representing the best extant representatives of 8 habitat types, and 83 sampling points on 39 restoration areas. Composition and structure of vegetation, and composition and relative abundance of small mammals, birds, and larval amphibians were monitored over 3 years for reference points and at 5-year intervals on restoration sites. Dissimilarity matrices that incorporated relative abundance were calculated to compare lands undergoing restoration to the reference conditions for each habitat. Non-metric multidimensional scaling was used to visualize the relationships of restoration to reference sites for each habitat type. Reference sites showed much lower variation both spatially and temporally than restoration sites. Sites sampled early in the restoration process indicated that multiple trajectories toward the reference condition were likely. Small-mammals and birds appear to be appropriate indicators of change for habitats such as shrub-steppe where there are clear linkages with herbaceous vegetation. For habitats subject to disturbance (e.g., flooding), local extinction and colonization events can alter species composition and abundance and move habitats away from reference conditions.

**O-14.3**

**Can we standardize the indicators used for evaluation of restoration outcome?**
Marianne Evju, Dagmar Hagen, Magni Olsen Kyrkjeeide, Berit Køhler
Norwegian Institute for Nature Research, OSLO, Norway

Within the very extensive and diverse jungle of ongoing restoration projects, an infinite number of indicators and registration methods are used to evaluate the outcome of restoration activities. The diversity of indicators is a challenge to any standardization of the implementation and evaluation of restoration outcome.
The SER Primer identifies key ecosystem attributes to be used as a basis for evaluating progress and accomplishment of restoration activities. Broad attribute categories could be a necessity due to the diverse types of restoration projects carried out, with varying objectives, different methods implemented, contrasting size and extent and different ecosystems. Nevertheless, broad attributes could make overall evaluations and assessments challenging and might hamper the development of sound and successful restoration. A wide range of indicators is used within each attribute category, reducing the opportunity for meaningful comparison of the effect of different restoration methods. Recent reviews of indicators used, and the methods employed to measure them, are lacking. In this study we carry out a systematic review of scientific papers addressing evaluation of restoration outcome. We identify ecological attributes used to evaluate restoration outcome and the indicators employed to represent these attributes. We include 98 studies published after 2010 from Europe or North-America implemented in terrestrial and limnic ecosystems, representing different types of restoration projects (habitat and/or ecosystem recovery, hydromorphology, water quality, management of semi-natural grasslands, and landscape reconstruction). We explore the main ecological attributes used to measure restoration outcome, and how indicators for these attributes are applied in relation to ecosystem and type of restoration project. Based on our findings we discuss whether standardization and streamlining of indicators is useful to improve the evaluation of on-the- ground restoration, or if this is not appropriate given the diversity of goals and ecosystem types involved.

**O-14.4**

**Response of bird diversity to 3D-LiDAR-derived vegetation and terrain characteristics on a post-mining site**
Vítezslav Moudrý, Miroslav Šálek
Czech University of Life Sciences Prague, PRAGUE, Czech Republic

Reclamation and restoration approaches predetermining the future character of emerging ecosystems are highly debated in connection with conservation strategies for post-industrial sites. In practice, among other ecological measures, vegetation structure and species diversity are the most frequently used to evaluate the success of restoration process. The vegetation structure is in turn affected by the terrain topography that can vary significantly among sites, depending on the adopted reclamation approach. Both terrain topography and vegetation structure are used to assess the species diversity and many studies have proved their importance. To model relationships between species diversity and ecosystems structure, however, both terrain topography and vegetation structure are usually represented by semiquantitative or categorial measures such as the magnitude of terrain depressions and/or vegetation cover of shrubs and trees. Moreover, they are spatially limited due to labour intensive field inspections

traditionally used by ecologists. Such approach is however inefficient. Vegetation structure and terrain topography can be more effectively estimated using remotely sensed data. While remotely sensed data can't always substitute field observations, they do markedly enhance our ability to study ecosystem structure over large areas and/or where repeated measurements are needed. In particular, airborne LiDAR has revolutionized measurement of the 3D structure of the ecosystems. Here, we used an airborne LiDAR of a spoil heap and its vicinity located in the Most mining district, Czech Republic, to derive vegetation structure metrics related to the height and density of vegetation returns and detailed information about terrain topography. We further used these variables to model predictors of variation in bird diversity and to examine the significance of these variables for predicting diversity of species with different nesting preferences. We believe that a greater adoption of remotely sensed data increases efficiency and reproducibility of results in the ecological restoration monitoring.

## S-22 -Natura 2000, habitat connectivity & climate change adaptation

### S-22.1

**Light & Fire LIFE project, restoring the fire-born and sunlit habitats in Finland, 2014-2020**

Sanna-Kaisa Rautio
Metsähallitus, Parks & Wildlife Finland, KUOPIO, Finland

The overall objective of the Light & Fire LIFE project is to improve the conservation status of habitats whose ecological characteristics are shaped by fire (fire-born habitats) or extreme solar radiation and luminosity (sunlit habitats). Restoration and management measures target several habitats such as forests, esker forests, coastal meadows, various open or semi-open coastal and dune habitats and dry grasslands. The project covers 69 Natura 2000 areas throughout Finland.

Main conservation issues being targeted are: Degradation of forest habitats due to effective fire prevention, forestry in esker forests, overgrowth of sun-lit habitats, overgrowth of previously open coastal areas, habitat fragmentation and isolation, *Rosa rugosa* occupying space from typical native species on sandy habitats.
Habitat restoration of Western taiga forest are controlled burnings, which will be carried out in 39 sites (total area ca 470 ha). Habitat restoration of sunlit habitats (34 sites, 345 ha) and Baltic sandy beaches (5 sites, 6 ha) will also include removal of invasive alien species.
Habitat restoration of *Pulsatilla patens* sites (one of the most vulnerable plant species in Europe limited to esker forests in Häme region in Finland), will improve the quality of existing sites and create new habitat patches for plants in 7 sites (8 ha). *Pulsatilla patens* has been assisted to disperse to the newly created habitat areas.
Habitat restoration measures will help to increase the population size of numerous species by offering them new areas to colonize, which will help to combat the effects of habitat fragmentation and isolation and increase the resilience of the populations to climate change.

### S-22.2

**LIFE+ FLANDRE: enhancing the Natura 2000 network by connecting cross border coastal dune sites**

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The coastal dune belt of the historical county of Flanders stretches across the present day state border between France and Belgium. Both in northern France and in Belgium, the Flemish coastal dune belt is strongly fragmented by urbanization and intensification of agriculture. The remaining dunes sites are, although in both countries mainly included in the Natura 2000 network, isolated from each other by built up areas, camping sites and quite intensively exploited agricultural areas. Fragile natural coastal dune habitats and populations of endangered species are more sensitive for degradation and extinction in a spatially and ecologically strongly fragmented area, the more so in an era of climate change and coastal squeeze. The Belgian Agency for Nature and Forests of the Flemish government and the French Conservatoire du Littoral and Département du Nord joined forces to conceive and implement the transnational LIFE+ Nature project 'Flemish And North French Dunes Restoration', abbreviated as 'FLANDRE' (from 2013, 09-02 until 2020, 03-01). The main objectives of this project is to develop a legal basis for a joined protection and management of the coastal dune belt between the French port of Dunkirk and the Belgian sea-resort of Westend as a cross border nature park and to provide a masterplan for it. The draft of masterplan sketches opportunities to realize ecological connections and to restore natural processes, such as Aeolian dynamics. Transition areas between coastal dunes and the sea on one side and between the dunes and the polders on the other side get special attention. At the same time land purchase, management planning and habitat restoration works are realized on the field in order to strengthen the existing Natura 2000 network within the cross border project area. Several communication and networking actions aim at raising the awareness of the international importance of the project site.

**S-22.3**

**Mountain hay meadows: assessing the loss of surfaces and ecosystem services in Iberian areas**
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Hay meadows, agro-ecosystems established and maintained by human secular actions of extensive management, are disappearing all over Europe, especially in mountain areas where they represent key High Nature Value Farming systems for biodiversity and ecosystem services. In recent times, also mesophile hay meadows in South-West Europe, an European priority habitat registering a poor conservation status, have lost significant part of their area. This disappearance is due to abandonment, intensification or urbanisation, driven by changes in land management and rural socio-demographic decline.
This study is aimed at assessing the loss of mountain hay meadows in the North of the Iberian Peninsula and its consequences for ecosystem services, focusing on selected pilot areas currently protected as Natura 2000 sites. A diachronic analysis of these habitats was carried out through detailed land use mapping for three different periods, from the 1960s to the present, representing areas covered by hay meadows over time. Once identified, land use changes during the time under consideration have been quantified and analysed, as well as the drivers responsible for those changes. The conceptual framework of the Millenium Ecosystem Assessment was then applied to identify and discuss the most relevant consequences of change on ecosystem services.
Results showed that, over the last 60 years, some study areas have lost up to 68% of hay meadows progressively, although at a higher rate in the latest years. A relationship between abandonment and slope and distance to inhabited areas has been also observed. Findings suggest that the observed abandonment process may lead to a loss of biodiversity (domesticated species) and impacts in the supply of strategic ecosystem services such as genetic resources, safe and healthy food products, traditional knowledge or fire risk protection. Interactions between hay meadows loss, ecosystem services, demographic processes and agricultural structural changes are finally discussed.

**S-22.4** Hekkala

**S-23 -Cost-effectiveness of ecological restoration based on ecosystem service**

**S-23.1**

**Cost-effectiveness of different restoration approaches - an example from LIFE to alvars project**
Annely Esko[1], Aveliina Helm[2]
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Estonia has experienced a major loss of alvar grasslands (6280* Nordic alvar and precambrian calcareous flatrocks) in the past 40 years due to abandonment, forestation and inadequate grazing regime. Main threat to these valuable diverse calcareous grasslands is overgrowing with junipers and pine trees after grazing has ceased. This has caused the loss of nearly 85% of the alvar habitat in Estonia.
LIFE to alvars project is targeting the key areas of alvar habitat in Western Estonia aiming to restore 2500 hectares of alvars and re-establishing grazing in the restored areas.
To obtain maximum benefits for biodiversity and ensure spontaneous colonisation of target species, landscape-scale species dispersal was considered when selecting sites for restoration. Landscape-scale restoration allowed to save from species re-introduction efforts and also ensured the development of self-sustainable, viable habitats. Main challenge of the project was to match the large areas needed to restore (2500) with allocated funds and period. To achieve the most cost-effective restoration, it was decided to use the forestry and agricultural machinery instead of previously used hand-held machinery. However, as there was little or no previous experience in alvar restoration using such heavy machinery, and this also met strong resistance from local people at the beginning, who preferred less invasive, but very laborious restoration by hand. Four different types of machinery were successfully tested and are now used in alvar grassland restoration process. In 3,5 years 80% of the targeted area has already been restored. As the work is quicker, less expensive and with better quality compared to the restoration done by hand, the method has now also gained support of local people. We provide overview of costs of different tested restoration methods and discuss the practices that we consider the most effective regarding biodiversity and restoration cost.

**S-23.2**

**Cost: effectiveness analysis of ecological restoration in alpine ecosystems**

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Alpine ecosystems are often considered as remote wilderness. The ecological, social and economic value of these areas are indisputable. Alpine ecosystems in the north have large biodiversity values, holding rare and vulnerable species and unique ecosystems. At the same time the areas have a long and diverse history, traditionally they have been used for grazing, haymaking, firewood and hunting. Today, ceasing land-use and over-growing put pressure on traditional semi-natural landscapes. During the last century habitat degradation from heavy development projects like hydropower plants, mining, military training, roads, power-lines, railways, cabins and hotels has increased. Effects from climate change and invasive species works on top of these. As the pressure on alpine ecosystems have been described and the effects on landscape and biodiversity is documented, the need for restoration is evident. Single restoration projects are carried out, both in semi-natural landscapes and in sites severely disturbed by technical development. The increasing need and allocation of resources to restoration projected from the national and international commitment call for prioritization of money and efforts. Restoration of alpine areas is challenging due to harsh climate conditions, short growing seasons and limited access to native plant material. In this presentation I will discuss how indicators for cost-effective restoration will apply in alpine ecosystems. Restoration in alpine ecosystem has so far been mainly been single projects, and ad-hoc initiatives. A cost-effective restoration in these areas call for strategic planning. The overall wilderness characteristics, slow response to restoration action, and distance to large settlements might challenge the prioritization of restoration in these ecosystems, compared to more centralized and high productive areas.

**S-23.3**

**TERECOVA: Cost-effectiveness analysis to prioritize restoration actions in Mediterranean landscapes**

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Due to a large amount of degraded lands and limited availability of monetary resources designated for ecological restoration, definition of priority areas for restoration is a key step towards effective land use management. At large spatial scales, decisions commonly rely on expert advice and ecological criteria, paying scarce attention to stakeholder visions and aspirations. In addition, approaches that take into account the costs and benefits of different restoration options in a transparent way are largely lacking. We have developed a methodological protocol to identify priority areas for restoration based on the cost-effective analysis (CEA) using a participatory approach. This protocol aims at facilitating the decision-making process, addressing ecological, technical, socio-economic and cultural criteria and responding to society demands. We established a stakeholder platform in the Crevillente Management Area (CMA), a 225,000 ha semi-arid zone in south-east Alicante (Spain), and asked them to identify and rank the ecosystem services (ES) provided by eight non-urban landscape units present in the region. Stakeholders identified 23 ES. We obtained mapped data on these criteria from existing databases using a 100x100 m grid, and aggregated the data to obtain the integrated provision of ES for each landscape unit. Using Multidimensional Scaling Analysis, we then identified common degradation syndromes for each landscape unit. Finally, we calculated the monetary cost of restoration actions and estimated the effectiveness of these actions as the increase in the integrated value of ES. Results of the analysis will be delivered back to the stakeholder platform to refine the protocol, reach consensus on the priority areas for restoration, and promote engagement of the public and private sectors in ecological restoration actions. We appreciate funding received from the Ministry of Economy, Industry and Competitiveness and European Regional Development Funds (FEDER), project ‘Tools for planning ecological restoration in the Region of Valencia’ (TERECOVA; CGL2014-52714-C2-1-R).

**S-23.4**

**From cost-efficiency to cost-effectiveness - ecology and economics in systematic restoration planning**

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Achieving even a small proportion of the global 15% restoration target seems to be a huge task. Trying to avoid harmful opportunism while seeking beneficial opportunities is challenging our current operational practices for cost-effective allocation of resources for ecosystem improvement. Here we will present an example of how cost-effectiveness of ecosystem restoration and management actions can be systematically approached in spatial planning. The case example describes an analysis where a national scale conservation area network, consisting of the protected Natura 2000 areas in Finland, is prioritized from the perspective of identifying areas where to focus the ecosystem restoration and management resources. In this analysis we spatially apply a habitat-specific data on restoration effects and costs determined by over 100 experts in the Finnish restoration prioritization working group that investigated cost-efficiency of restoration and management of different habitats. We have further developed this data to produce spatially defined ecologically cost-effective solution: combining the expert group’s results with spatial

habitat data and ecological prioritization tool (Zonation) allowed us to move from habitat specific cost-efficiency to multi habitat (67 different habitat types) cost-effectiveness. Instead of looking at habitat specific improvement costs per unit of area, we aimed to identify protected areas where restoration and management actions would provide largest increase in the total ecological value of the protected area network. The presented analysis demonstrates a systematic planning process to cost-effectively approach the 15% restoration target. In addition to identifying high restoration and management potential on maps, the systematic analysis method offers quantitative measures to investigate the trade-offs related to complex conservation decision making processes. Results of the analyses are currently used in real-life planning processes by the Parks and Wildlife Finland, governing the protected Natura 2000 areas in Finland.

**O-15-Ecological engineering**

**O-15.1**

**Innovation and Challenges for Soil Bioengineering in a Changing World**

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Riverbanks are assuming a large number of important ecological functions: biodiversity support, resistance to invasion, ecological corridors, biomass production, water purification, temperature regulation, flood control, and recreation. Besides hard engineering, soil bioengineering techniques for riverbank protection are very old nature based solutions and have been used for centuries throughout the world. First thought of mimicking nature to fulfil the function of erosion control, soil bioengineering techniques are now also formed to assume some of the other important ecological functions of riverbanks.
Using mostly concepts and tools from restoration and functional ecology (but also from engineering and hydraulic), we conducted a set of studies and experiments (in greenhouse and on real works) that aimed at characterising and maximising the contribution of riverbank bioengineering techniques to some of these ecological functions, including biodiversity support, resistance to invasion, resistance to drought and erosion control.
We assessed the capability of several types of managed and mineral riverbank to support both common (terrestrial plants and beetles, macrobenthic communities) and endangered biodiversity (*Myricaria germanica* and *Typha minima*). Regarding resistance to invasion, we studied the potential of bioengineering techniques to resist to the pressure of an invasive rodent (*Myocastor coypu*), and to outcompete Japanese knotweeds. Summer drought should increase with climate change, and is a major threat for bioengineering success; we then studied the resistance of *Salicaceae* and *Tamaricaceae* populations to harsh drought. Finally we worked to maximize erosion control function of these techniques by implementing bioengineering works in steep slope rivers (5-10%), and by assessing past shear stress resistance to flood.
Our results show that soil bioengineering techniques can be definitely thought as a nature based solution for assuming both erosion control and main ecological functions of riverbanks, and are thus promising in the achievement of these complex human goals in a context of global change.

**O-15.2**

**Long-term effects of liming on soil microarthropods in forest soils**

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Long-term effects of liming on soil microarthropods in forest soils
Henk Siepel, Roland Bobbink, Arnold van den Burg
Liming is used as a restoration measure for the remediation of acidification due to atmospheric deposition of sulphur and nitrogen ($NO_x$ and ammonium) compounds. In 1985 and 1986 lime has been applied in a Dutch Scotch Pine forest stand on a mineral poor and weakly buffered soil. In a randomized block design 4 levels of liming have been applied. Each treatment has been replicated three times. Liming quantities were: 3, 6, 9 and 18 tons per hectare and an untreated control, so in total 15 plots. Plots are 550m$^2$ in size and were sampled in October 2017, 32 years after application of lime treatments. In each plot 4 samples were taken following a standard procedure. All specimens have been identified to the species level and grouped into life-history strategies and feeding guilds. Recent results from other ecosystems on dry mineral poor soils revealed P limitation under continuous N deposition and acidification, including the loss of the soil buffering capacity and release of aluminium. Liming however, may limit P availability even more. We observed not only significant differences in soil chemistry, litter stratification, and the forest understory, but also in density and species composition of soil microarthropods. The long-term consequences of liming as restoration measure on mineral poor soils will be discussed.

**O-15.3**

**The use of mine spoils in the quarries restoration in Mediterranean environments: problems for revegetation**

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In quarry restoration, the spoil materials are commonly used as substrate for restoration of the affected areas. These substrates have a high stoniness that determines their hidric functioning and amount of water reserve. However, revegetation actions often promote seeding with commercial herbaceous of fast growth and high water requirements. The combination of stony substrates and dense herbaceous cover can limit the efficiency of woody plantations. This project aims to establish treatments to reconcile stony substrate water limitations with woody plantations. The mastic (*Pistacia lentiscus*) has been used as reference woody species, that has been planted in containers of 25 L with stony substrates where different treatments have been tested. A treatment series is intended to determine the effectiveness of the application of different types of mulch in reducing herbaceous development and water conservation in the system. Another series of study concentrates on establishing whether seedling with a commercial herbaceous species (*Festuca arundinacea*) or with native species (*Brachypodium phoenicoides*) can determine differences on system evapotranspiration.
The results show that during a period of drought, soil water loss is much faster and higher when there is herbaceous cover, although there are no differences between herbaceous species tested. Mulch materials, gravels in single or double dose, or pine bark, determine a lower water loss compared to controls without mulch. However, bark is more effective than gravel though economically more expensive. The obtained information can improve the revegetation process of stony substrates, which are usual in quarry restoration. The extractive sector would be the main beneficiary of the results.

**O-15.4**

**Ecosystem restoration by temporary facilitation of coastal vegetation and shellfish reefs using biodegradable habitat structures**

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Worldwide, coastal zones are increasingly at risk from flood disasters due to climate-induced sea-level rise and increased storm intensity. Growing recognition of the importance of nature-based flood defense for coastal protection has created a need to restore degraded coastal wetlands in flood-prone areas. Establishment of the foundational species that engineer these systems is however hampered by physical and biological thresholds. Restoration of these habitats is very challenging, because self-sustaining feedbacks generated by habitat-structuring organisms, only work beyond a certain minimum patch size and density.
To overcome this threshold, we developed innovative multi purpose ecosystem restoration elements (BESE-elements). One essential feature of these multi purpose elements is their biodegradability. They are designed to temporarily provide essential habitat characteristics for new settlement of foundational species. After successful recruitment and growth, the adults will provide these habitat characteristics and there is no more need for artificial structures, hence the elements can degrade.
We tested restoration of several foundational organisms by using BESE-elements in multi-year field experiments. Quantitative experiments where performed with intertidal blue mussel beds (*Mytilus edulis*), salt march vegetation dominated by *Spartina anglica* and beds of the Eastern oyster (*Crassostrea virginica*). Furthermore, proof of principle trials where performed with mangrove species and aquatic vegetation species (both submerged and emergent).
Our experimental results show that the BESE-elements can facilitate recruitment and multi year survival of several foundational organisms, among which are blue mussel beds, salt march vegetation and Easter oyster beds. This was always tested against controls without artificial structure that yielded no recruitment or much poorer survival. It also became apparent, however, that for each species specific deployment techniques of the artificial structures are essential for restoration success.
We conclude that the use of temporary establishment structures is a promising approach for the recovery of vital coastal ecosystems and their services.

**Posters**

**P-01**

**The effects of seismic lines on soil properties and permafrost in peatlands of NW Alberta**

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Linear features such as seismic lines built through boreal peatlands can have direct impacts on soil moisture and thermal dynamics, permafrost, ecosystem functions such as carbon accumulation and climate regulation, and vegetation recovery. Removal of vegetation reduces water intake and decreases evapotranspiration, which may contribute to higher soil moisture conditions on seismic lines than in the adjacent ecosystems. High moisture makes soils more prone to compaction and subsidence, which further affects moisture and thermal regimes. Within permafrost regions, these impacts may contribute to permafrost thaw and damage. All of these factors lead to reduced chances of vegetation recovery. The objective of our research is to assess the impact of seismic lines in treed peatlands on environmental conditions (light levels, soil moisture, temperature, permafrost presence), and on plant recovery, in comparison to the adjacent treed parts of the peatlands. We also assess if the orientation of the seismic lines (N-S vs. E-W) affects the extent of these impacts. The study is located in the peatlands of northwestern Alberta, Canada, where seismic lines are ubiquitous. We sampled along 22 transects (11 oriented N-S and 11 E-W) running perpendicularly to the seismic line, and extending 75 meters away from the edge of the line in both directions. Preliminary analyses show that soil temperature is lower, and soil moisture and light are higher on the lines in comparison to the adjacent peatland. Permafrost is less likely to occur under the lines in comparison to the adjacent peatlands (especially on the N-S-oriented lines), implying deeper active layer due to more prominent permafrost thaw under the lines. Global warming and positive feedbacks may lead to further permafrost thaw and release of carbon through greenhouse gas emissions. Subsequent analyses will assess the effects of seismic lines on plant recovery.

**P-02**

**Synthesizing cumulative threats to restoration and conservation of boreal Woodland Caribou habitat in Canada.**

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A growing and diverse number of anthropogenic impacts is affecting populations of Woodland Caribou (*Rangifer tarandus caribou*) in Canada. Restoration and conservation activities are needed to maintain critical habitat. We used the ISO 31010 Bow-tie Risk Assessment Analysis Tool (BRAT) to visually synthesize and evaluate cumulative anthropogenic effects on natural regulation of caribou populations. BRAT frameworks offer a way to analyze cumulative ecological effects at the landscape level while considering the most relevant policy options. Our BRAT synthesis focused on the threatened meta-population of Boreal Caribou in Northeastern British Columbia; it outlines knowledge and regulatory gaps. Climate change emerges as a factor with major knowledge gaps in this context, as well as regulatory uncertainties that currently challenge more precise quantification of risks. The BRAT framework can support decision-making on caribou protection and provide a starting point for analyzing other cumulative effects.

**P-03**

**Degradation process of Fescue-forbs rangeland in mountain steppe of Mongolia**

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The total area of *Fescue-forbs* community in Mongolia is 10 million hectares, in account of 8.5% of total rangeland area. *Fescue-forbs* community is the main type of rangeland in mountain steppe. The Mongolian rangeland has degraded for the last decades mainly due to overgrazing and climate change. The main objective of this study is to determine the change of plant community and reduction of abundance and productivity of dominant specie *Festuca lenensis* in last two decades (from1995 to 2015). The main species and main plant functional groups were completely changed in *Fescue-forbs* rangeland in comparison to last two decades. The climate was fluctuated during the study period that was effected in plant growth and biomass productivity. The cover of *Festuca lenensis* was decreased by 99.5% and biomass percentage was decreased by 91.5% in this plant community in last 20 years' time period. The total grass cover has decreased by 95.5% and percentage of grass biomass has decreased by 51.7%. Abundance of *Poa attenuatha, Koeleria cristata* became very few, but *Helictotrichon Schellianum* was destroyed. The species are preferable, desirable, palatable grass species for Mongolian livestock. The *Potentilla acaulis* is main degradation indicator species that is increased by 83.2%. Also some of degradation indicator species such as *Heteropappus altaicus* has increased by 57%. *Arenaria capillaris* is a species with grazing tolerance this was increased by 22.4%. Vegetation cover and biomass difference was significant (P>0.0001) during our study years. Our study aim was to reveal a degradation process of *Fescue-forbs* plant community in mountain steppe of Mongolia.

**P-04**

**Trees in Niger agroforestry systems to restore soils and enhance farmer resilience to climate change**

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Semi-arid and arid countries, like Niger, is characterized by low soil fertility. Soils used for agriculture are sandy (90%), exposed to rapid degradation and very prone to wind erosion and runoff. Therefore, trees are extensively used by farmers to conserve soils, restore degraded lands and to improve soil fertility. There is a need to know how effective are different tree species used for soils restoration in maintaining and improving soil quality and farmer resilience to climate change. A two years farmers field experiment (2015-2016) was conducted to investigate the impact of tree species on soil fertility and crop yield considering three factors (tree species, crown positions and fertilizer management) which were considered in split-plot design with three replications. Five tree species were investigated: *Annona senegalensis, Balanites aegyptiaca, Faidherbia albida*, *Guiera senegalensis*, and *Piliostigma reticulatum* and four levels of fertilizer were used: two fertilizer micro-dosing (DAP (2g $hill^{-1}$) and NPK (6g $hill^{-1}$)), manure (20g $hill^{-1}$) and control. Results showed that the legume trees (*P. reticulatrum* and *F. albida*) improved soil quality and fertility in the long term far better than other species (pH, organic carbon, nitrogen and phosphorus). We found significant differences between species for millet grain yield improvement. *P. reticulatum* and *F. albida* had higher grain yield (1011 and 1005 kg $ha^{-1}$, respectively) in 2015 than other tree species. Fertilizer application improved crop performance than the control and both fertilizer micro-dose rates increased grain yield (748 kg $ha^{-1}$) better than manure (615 kg $ha^{-1}$). However, tree species combined with fertilizer micro-ding improved more the grain yield and is an effective fertility management practice. Trees selection in farm agroforestry system should not only be guided by mere objective of soil restoration but also by tree species that better improve soil quality, maintain durability and to enhance farm resilience to climate change.

**P-05**

**The Role of Restoration and community Resilience to climatic shocks: Experience from Ethiopia.**

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Land degradation, deforestation and soil erosion is a rampant phenomenon in Ethiopia. These situations of overexploitation of natural resources have led the country to vicious circle of poverty. To reverse this problem, the government with donors has developed a land restoration program to be implemented in the most affected areas. The last ten years there has been tremendous effort in landscape restoration and halting land degradation through sustainable land Management programs (SLM). The main objective of this study was to assess the impact of restoration efforts on community resilience to climatic shocks. For this study 34 micro-watersheds have been considered from all agro ecological zones of Amhara region, Ethiopia. To frame the study, stratified clustered sampling was applied. The assessment was made during the 2015/16 drought which has been rated as one of the worst drought in Ethiopian history. The result was summarized in seven thematic areas; technology adoption status by community, sediment retentions, impact on biodiversity and biomass, livestock productivity, enhanced water flow, soil fertility change, and protection of the environment. The study revealed that the restoration efforts made the last ten years has positive impact in maintaining soil fertility, increase productivity both in crop and forage biomass, base flow yield of water resources, reduced sediment yield and increased ecosystem services. Through this community resilience to drought and shock has increased. This was clearly observed in the 2015/16 drought and the communities in restored landscapes were be able to cope up with the climatic shock in drought prone areas of Amhara, Ethiopia.

**P-06**

**Mitigating future ecological impacts for restoration: resilience assessments and fire risk modelling of alpine peatlands**

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Australian alpine peatlands are restricted to the south-eastern mainland Australian Alps and Tasmania. They are listed nationally as an endangered vegetation community due to limited distribution, past loss and threatening processes. Research has shown that peatlands have suffered a reduction in ecological function and resilience across most of the geographic distribution; this is due to myriad impacts such as pest animal species (specifically horses, pigs and deer), weeds, past wildfires, altered hydrological regimes and climate change. As a result, restoration of these communities is a national priority and detailed assessment of the relative risks and appropriate restoration responses is being undertaken.
Whilst restoration activities have now been undertaken on many of these peatlands, reducing the impacts of future threats to their persistence, in particular wildfire, is now a priority. It is also a specific challenge in the face of changing climate regimes and increased frequency and intensity of wildfires.
The 'Alpine Peatlands Fire Risk Mitigation Planning Project' initiated by Parks Victoria aimed to improve the

management of alpine peatlands by reducing the impacts of wildfire, hazard reduction burns and fire control activities. The project comprised six steps:
1 Analysing factors that influence the susceptibility, flammability and fire intensity
2 Analysis and prioritisation of alpine peatlands based on their resilience and specific values
3 Fire scenario modelling
4 Review of fire prevention and suppression tactics
5 Incorporating peatland-specific fire management activities into the statewide fire planning database and activities
6 Training, implementation and review of guidelines under wildfire scenarios.
This presentation will describe the project outcomes and how they have informed and improved fuel management planning activities such as zoning and hazard reduction burning frequency. The implementation of tactics and planning tool that mitigated risk to alpine peatlands during bushfire response in the 2017 wildfire season are also outlined.

**P-07**

**Sustainable management to reduce grasslands grazing pressure and improve household income in northern China**

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Increasing livestock grazing pressure in the agro-pastoral region of northern China has resulted in 90% of the pastoral land there being degraded. To examine possible ways to sustainably manage these expansive areas, a formal survey of sheep farmers was conducted, and data from experimental trials were obtained in Hebei Province of northern China. The objectives of this project were to analyze the current livestock production system in northern China and through the use of models provide optimal alternatives for livestock production management. The framework of analysis was based on a multi-stage economic model. The farm survey showed that farmers in this region both cultivate cropland for grains and green feed, which could provide plentiful animal feed during years with poor, low quality grassland growth. Local grassland utilization was communal with yearlong grazing and small amounts of concentration supplements and fodder given for animal survival during winter. Farm survey data were used to run farm management models. The *StageONE* Model analyzed annual feed supply and demand and showed that energy and nutrient supply were always deficient from late-September to May with the current farming system because of poor forage nutrition, low feed availability and inadequate animal management during pen feeding. The gap of the annual feed supply and demand could be reduced by using improved sheep breeds for meat production instead of current breeds that produce wool and poor meat quality. The *StageTWO* Model showed that maximal profits could be achieved by using a combination of seasonal grazing at a grazing intensity of 5.4–6 sheep $ha^{-1}$ and pen feeding. In addition, changing lambing time to November would reduce grazing pressure during the summer, which will be beneficial for grassland restoration and enhanced ecosystem services.

**P-08**

**UN University Land Restoration Training Programme (UNU-LRT): Who are we and what do we do?**

Berglind Orradottir, Halldora Traustadottir, Isabel C. Barrio, Hafdis Hanna Aegisdottir
UN University Land Restoration Training Programme, REYKJAVIK, Iceland

The mission of the United Nations University Land Restoration Training Programme (UNU-LRT) is to train specialists from developing countries to combat land degradation and restore degraded land, and to assist strengthening institutional capacity and gender equality in the field of land restoration and sustainable land management in developing countries. The programme is implemented jointly by the Agricultural University of Iceland and the Soil Conservation Service of Iceland, and builds on the knowledge and expertise of different partners by liaising with a wide range of Icelandic institutions, other UNU programmes, and international institutions and organisations. UNU-LRT is funded by the Icelandic Ministry for Foreign Affairs as a part of the government's international development cooperation efforts.
UNU-LRT works with individuals and partner institutions that have been identified as playing a significant role in land restoration and sustainable land management in developing countries. The core activity of UNU-LRT is an intensive six-month postgraduate training course on ecological restoration and sustainable management of ecosystems, held annually in Iceland. The training of the fellows is considered a contribution to institutional capacity building. In addition, UNU-LRT organizes short courses in partner countries in collaboration with partner institutions and organizations. These courses are designed and run in cooperation between specialists from UNU-LRT and the partner country, often engaging the expertise of former UNU-LRT fellows. Furthermore, UNU-LRT offers scholarships to support former UNU-LRT fellows to pursue graduate studies at Icelandic universities in land restoration and related subjects.
Since 2007, over 100 fellows from 13 countries in Africa and Central Asia have participated in and graduated from the six-month training programme. The fellows have, so far, come from Egypt, Ethiopia, Ghana, Lesotho, Malawi, Namibia, Niger, Tunisia, Uganda, Kyrgyzstan, Mongolia, Tajikistan and Uzbekistan.

**P-09**

**Results of ESD application as a restoration roadmap in desert region, Mongolia**

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Due to desire to put ground wealth of Mongolia into the economic turnover for last two decades, rangeland which is main fundament for the traditional animal husbandry has been decreasing year after year. The non-equilibrium system desert region needs more sound management technologies for restoration. According to Ecological Site Description (ESD) studies in this region and related concepts including State and Transition Models (STMs), *Haloxylon ammodendron* (C.A.Mey) Bunge is the key dominant functional species in ecological site groups, with deep sandy soils without argillic horizons and creates a scattered 'forest'. Species such as *Nitraria sibirica, Corispermum mongolicum, Eragrostis minor, Aristida heymannii* are present in the community. Our work aims to develop sound restoration technology for the deep sandy Ecological site group that shares percent of area impacted by Oyu Tolgoi Mining activities. We've started the restoration program using *Haloxylon ammodendron*, where saplings are prepared byseeds collected from local area and transplanted. Winter survival rate of saplings is 79.7% and in the fourth year width of leafage has increased by 8.7, maximum height by 2.0 and stalk diameter by 2.2. Functioning and the ecosystem service values are being monitored based on the STM which covers the key functional shifts and dynamics of alternative community phases.

**P-10**

**Effects of deforestation and subsequent devegetation on springfed stream ecosystems in Iceland**

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Large-scale deforestation, loss of vegetation cover and subsequent soil erosion has been an ongoing problem in Iceland through centuries. Loss of vegetation and soil does not only affect the function of the terrestrial ecosystems, but can potentially also affect other linked ecosystems, such as freshwater streams in the same area (catchments). The present study was conducted on eight first order headwater streams and their catchments in southern Iceland where four catchments had been eroded and four had remnant woodland vegetation and soils. The goal was to compare: a) annual litter production within the catchments, b) annual litter transport into streams, c) the decomposition activity of the stream biota and d) biodiversity and functional diversity of both decomposer- and total benthic stream invertebrate communities. The main findings of the study were that terrestrial deforestation/soil erosion has significantly reduced annual litter production (93%) and thereby limited the potential energy inputs into the freshwater ecosystems. Litter transport to streams was, however, not reduced as much as expected (64%) because relatively higher fraction of the annual litter production is blown into the streams in the open, eroded, catchments. Litter decomposition rate was significantly higher in woodland streams and total invertebrate biodiversity or abundance was not strongly related to decomposition responses – but functional diversity was! Total energy inputs in streams in deforested/eroded catchments were smaller, both because of less litter inputs and because of less abundance of shredders.

**P-11**

**Phytogeographic Gradient Analysis in Guatemala: Baseline for Ecological Restoration at the face of Climate Change.**

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The Tertiary tectonic evolution of Guatemala in Nuclear Central America, led to the arrangement of complex bioclimatic zones along elevational and continentality gradients. Biotic distribution and composition along such gradients, is resultant of long term evolutionary arrangements, associated to physiologic traits and biogeographic origins. Accelerated planetary change after the 1950's, due to human impacts, is leading to progressive alteration of planetary boundaries, such as Biosphere Integrity and Climate Change, critical for Earth's functioning and human well-being. Modelling of biotic responses to global modification of Holocene climatic parameters, predicts major vertical shifting of vegetation along elevation. However, recent paleoecological data from Latin America is informing that such responses are non-linear and geographic dependent, as it has been observed from paleobotanical reconstructions along Glacial-Interglacial cycles during the Pleistocene. Thus, vegetation inventories become a critical tool to assess biotic responses related to increasing environmental variability. In Guatemala we are studying vegetation distribution and composition along environmental gradients, and assessing responses as a function of

one or a combination of the following variables: Climate variability, elevation, geographic tectonic configuration, and phytogeographic origin (which is associated to physiological constraints). Our first environmental gradient analysis findings along Las Verapaces Region, suggest that the distribution of non-generalist plant species, which define vegetation belts, is explained majorly by its phytogeographic origin, which is in turn associated to geophysical heterogeneity (elevation, climate and tectonics). For example, there is a positive correlation between elevation and Laurasian plant species, and negative regarding Amazonian, while Andean are found majorly at intermediate elevations. We are extending this study to different environmental gradients in Guatemala, such as the Cuchumatanes Highlands to Pacific Coastal Lowlands, as a mean to establish an ecological baseline for restoration purposes, which will become critical to assess future biotic adjustments due to climate change.

**P-12**

**Assessment of pond restoration with the 'recovery wheel'**
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A pond is a stretch of stagnant fresh or salted water, smaller than a lake, with little depth, natural or resulting from human activities The biodiversity and functioning of both natural and artificial ponds are degraded worldwide by several factors such as the increase of suspended particulate matter, eutrophication, pollution, invasive species,...Lately, these phenomena are speeding up due to human intervention and global warming. However, these ecosystems play important ecological roles and provide many ecosystem services; therefore their restoration is important issue. Many restoration criteria should be take into account for evaluating the success of the restoration project and its integration in the natural environment. The 'five-star recovery' system is a tool designed by the Society for Ecological Restoration to evaluate whether the ecosystem is on a self-organizing trajectory to its recovery. This recent system reveals that most restoration projects take few of the eighteen available criteria into account. This poster is a student project which aims to analyze different pond restoration projects worldwide, to review the main restoration methods used and their results. Also, the poster will analyzed several restoration projects by applying the 'five-star recovery' system to determine how many restoration criteria were used and appear to be more important for the success of the operation. The lack of interdisciplinary points of view can have a harmful effect on the restoration

**P-13**

**Vegetation and soil monitoring in Iceland for early detection and intervention of land degradation**
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Land degradation is a serious problem in Iceland with almost half of the country classified with considerable or severe erosion. Currently, a long-term national vegetation and soil monitoring programme (GróLind) is being developed in Iceland. GróLind is managed by the Soil Conservation Service of Iceland (SCSI), already funded for 10 years, and based on an agreement between the SCSI, Ministry of Industries and Innovation, the Farmers Association of Iceland and the Icelandic National Associations of Sheep Farmers.
The aim of the programme is to 1) assess the conditions of vegetation and soil resources in Iceland and examine changes over time, and 2) develop indicators for sustainable land-use. The focus will be on monitoring variables linked to ecosystem functions and structure to estimate the conditions and detect any changes over time. The programme will be based on an adaptive monitoring approach, span several spatial scales and focus on land-use, vegetation and soils. Satellite images will provide large-scale data, while drones and on-site ecosystem analyses, by land users and specialists, will be used for obtaining higher resolution data. The programme will develop indicators of sustainable land-use, using experiments, available information and results from the monitoring programme. Emphasis is placed on collaboration with stakeholders and among institutions.
The data will be used to identify areas where changes in land-use and/or revegetation efforts are needed. The overall goal is to use these ecological data to promote, in collaboration with stakeholders, sustainable land management in Iceland.

**P-14**

**Forest restoration monitoring and generation of adaptive management recommendations through images obtained by UAV/LIDAR**
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Monitoring and evaluating restoration is a challenge especially in large-scale projects, but the remote monitoring of indicators with the use of synoptic, multispectral and multitemporal data allows us to gauge the trajectory of the restoration process. The objective of this study was to develop a methodology for monitoring forest restoration through images obtained by Unmanned Aerial Vehicle (UAV) and Light Detection and Ranging (LIDAR), in order to generate accurate adaptive management recommendations. The study was carried out in private forest restoration areas with more than 48 months of implementation, in the state of Bahia and Espírito Santo, Brazil. We used images of Canon S110 NIR camera on UAV and a composition of LIDAR data for monitoring. The monitored restoration indicator was the land cover separated in three classes: canopy cover, bare soil and grasses cover. Images were classified with Maximum Likelihood (ML) and Random Forest (RF) algorithms. The values "**?**"**?**of the classification accuracy (Kappa Index and Overall Accuracy) and visual evaluation of the images were excellent for all combinations of methods (UAV or LIDAR) and algorithms used. When algorithms efficiency was compared, RF presented better performance than ML with significant difference (UAV: Z = 14.55 and LIDAR: Z = 5.74), but when imaging methods (UAV and LIDAR) were compared, there were no significant differences. For generation of adaptive management recommendations, the area occupied by different land cover classes was calculated by restoration polygon and an expert system was elaborated to define recommendations through ArcGIS software. There was little difference between recommendations generated by UAV and LIDAR images and the most common recommendation was weeding (grass control) combined with densification (planting with native species). The monitoring methodology suggested by this study was efficient, and can be considered promising to monitor areas in restoration process, especially on a large scale.

**P-15**

**Nutrient enrichment and changes in plant species at >300 years abandoned farms in Iceland**

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Iceland was the last large island colonized by man in the world. The settlement of Iceland by Viking farmers has occurred since 870s AD. Vikings were sheep-, horse-, and cattle farmers while grazing was the dominant form of livestock feeding in the past. How long can be such effects of farming activities detectable on plant species composition, biomass and soil chemical properties after abandonment of the farms?
We studied seven abandoned farms in Rangárvellir, in the close vicinity of volcano Hekla in southern Iceland. These farms were abandoned because of volcanic eruptions and tephra deposition, extreme dust storms, or earthquake, since 17th to 20th century. In all farms, we recorded differences in plant species composition between vegetation on ruins of farms or close to ruins and control vegetation outside the farms. Species typical for ruins of farms were Alopecurus pratensis, Equisetum pratense, E. arvense, Rumex acetosa, Elytrigia repens, and Poa pratensis. Species typical for controls outside of farms were Festuca vivipara, Luzula multiflora, Carex bigelowii, Potentilla crantzii, and Galium boreale. Plant available content of P, K, Ca, Mg, Zn, Cu, Fe, Mn, and total N content were higher in upper 10 cm soil layer on abandoned farms than in controls outside the farms. Content of P, K, Ca, and Mg was higher in above ground biomass from abandoned farms than from controls and vice versa in the case of Fe, Mn, Zn, and Cu.
Changes in the vegetation, plant nutrition and soil chemical properties caused by farming activities can be visible at least for several hundred years after the farm abandonment in Rangárvellir, Iceland. Such changes can be visible even in the area with volcanic eruptions and with tephra deposition.

**P-16**

**Monitoring Mitigation Peatlands/Wetlands in Northern Minnesota, USA**

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Wetland mitigation policy in the U.S. is based on a three-step process---avoidance, minimization, and compensation, which must be observed in permitting projects with potential wetland impacts. Unavoidable wetland impacts due to road construction, mining and other development in northern Minnesota are compensated by creating or restoring mitigation wetlands. Regulatory performance standards for mitigation wetlands generally specify consideration of wetland hydrology, soils and vegetation. Given proper conditions and management, these factors gradually evolve over time to resemble natural wetlands. Therefore, to ensure compliance and mitigation credit, long-term monitoring of water levels and invasive species must be implemented.

However, monitoring challenges arise due to the increasing preference for larger watershed and landscape scale restoration projects. Long-term monitoring of these large mitigation sites can be difficult to conduct and fund, and according to state and federal regulatory agencies, is a primary reason for failure and non-compliance, resulting in subsequent wetland credit devaluation. As a result, there is an urgent need for cost effective and accurate vegetation assessment methods.

Studies conducted at the Natural Resources Research Institute have included monitoring of peatland/wetland

mitigation sites ranging in size from 0.25 to 200 hectares. Wetland assessment methods have evolved over time to become more accurate and efficient. Early studies relied on relevé surveys of randomly placed rectangular plots. To better quantify wetland plant community extent and quality, a revised technique utilizing the Step Point Intercept Method and GPS mapping was employed. With this method the Rapid Floristic Quality Assessment (FQA) could also be used to determine plant community vegetation quality. Current research is focused on the use of unmanned aircraft systems (drones) to photograph large mitigation sites annually, followed by limited ground truthing and analysis of the photos using GIS technology. This will allow for adaptive management such as water level adjustment and invasive species control.

**P-17**

**Drone mapping and multispectral indices as a tool for monitoring of mire ecosystems restoration**
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Mires as globally important ecosystems are largely disturbed by human activities like drainage, agriculture, forestry, peat cutting and urbanisation. Therefore, the conservation and restoration of mire ecosystems is highly actual.
Life project LIFE15 CCM/DE/000138 “Reduction of CO2-emissions by restoring degraded peatlands in Northern European Lowland - LIFE Peat Restore (2016-2020) established aimed to restore mire water regime, ecosystems and natural carbon balance. In Estonia the Läänemaa-Suursoo project site (area 3343 ha) selected.
Drone mapping included to the restoration project for following tasks: a) to map plant communities and their state over the study area; b) to follow changes in the plant communities after restoration and to relate these to the changes in carbon balance.
70 permanent plots (each contains three 2x2 m reveals) established for on-site mire plant communities monitoring and carbon fluxes measurements. Borders of the permanent plots marked by tape to visualize plots for drone mapping. Two different drone platforms are in use: a) *DJI Phantom 4 pro* with standard RGB camera; b) *SenseFly eBee* with *Parrot Sequoia* multispectral camera (4 spectral bands: green, red, red edge, near infrared).
Automatic pre-planned flight missions used for both drone flights. Captured images were processed with *Pix4D mapper* software to generate high-resolution georeferenced aerial photo mosaics and multispectral index maps.
Plant communities with different species composition and cover reflect spectral bands in different rate. Therefore vegetation spectral indices carry information about mire plant communities and can reflect state and disturbances of the mire ecosystems. First results indicate that normalized difference vegetation index (NDVI) reflect well density of mire communities grass and shrub layers. Sphagnum-dominated communities are characterized by relatively low NDVI values compared with sedge-dominated communities. Lower NDVI value tend to reflect more natural and valuable communities, higher NDVI reflects lower natural value of communities and stronger impact of drainage.

**P-18**

**Designing strategy and planning activities for and by a private restoration project in Chilean Patagonia**
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A case study of a nature restoration project conducted entirely by private means with no institutional, financial support or staff.

The setting: the ecosystem in region Aysén (Chile) was destroyed in the first half of XX century by deliberate fires and subsequent cattle grazing. It led to massive deforestation, biodiversity loss, acute soil loss, erosion - a silenced massive ecological disaster.

The project: a piece of this destroyed land (1800 ha) was bought in 2006 and assigned a private protected area status. A restoration project was designed, experience gained and added to the previous (UNEP) by the owners. 12 years after the successes are evident and further challenges identified.

The main success is the programme of reforestation for native woodland restoration, partly supported by Conaf under Chilean law 20283. To date more than 220 000 trees were planted with a survival rate of 85%. Restoration of wetlands, erosion control, good natural regrowth and active wildlife and birdlife can be added to the list.

Suitable principles, approaches, criteria and protocols were developed. A choice in restoration philosophy had to be made.

The ongoing challenges and solutions include: identifying achievable goals, prioritisation (such as protection for restoration vs conservation, observation and experience vs. scientific research, invasive species management, native restoration vs. novel ecosystem, etc.), ensuring privacy of nature, uncontrolled development of tourism in the region, relation to scientific world.

Operational solutions: different types of small independent organic energy and other sources, collection and storage of seeds for restoration, non-invasive nature observation methods, etc. Legal protection for future is considered at

present: stewardship vs. easements, In Rem right of conservation, compensation agreements.

Project management: adding to professional skills in international law and management courses on ecosystems and nature restoration, joining international restoration and land protection networks.

A tailor-made website developed : www.pichimahuida.info

**P-19**

**Restoration planning in Western taiga habitat type in Estonia**
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Western taiga habitats include natural old forests as well as young forest stages that naturally develop after disturbances (e.g. fire or storm). According to EIONET (2018) Western Taiga habitats cover almost 27 000 $km^2$ of forests in Boreal region, which is 21.6% of total terrestrial Natura 2000 area (124 645 $km^2$) (Natura Barometer 2017) in member countries where it occurs: Estonia, Finland, Latvia, Lithuania and Sweden. By the range of this habitat, it is considered in favorable status in member countries but overall assessment, including structure, functions and future prospects, shows that conservation status is unfavorable for the habitat in these countries. Estonia has 7785 $km^2$ (17.2% of terrestrial area) of Natura 2000 areas, which makes Western taiga with 700 $km^2$ (9% of Natura areas) the most represented forest habitat type. The main pressures and threats for this habitat are removal of dead and dying trees (CWD), thinning of tree layer and forestry clearance. The high importance conservation measures for future include: restoration of forest habitats, adaptive forest management, establishing wilderness areas and allowing different succession stages.
For better understanding of different forest structures in Western taiga habitat type, we established 100 research plots within the Estonian Network of Forest Research Plots (ENFRP). Besides traditional methods, these plots are also used for detailed monitoring of CWD and its decomposition. The data of forest structure in different sites gives an opportunity to develop better instructions for ecological forest management and restoration planning.
Usually forest data describes the mean values (height, diameter, age) in forest stands in Estonia. Alternatively we could use more unconventional way and take forest structural elements at the focus of forest inventory also. For management decisions, forest structure can be assessed from LIDAR measurements also and this can be combined with biological knowledge.

**P-20**

**The ENABLE Consortium: integrated landscape management based on sustainable business models**
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Landscape degradation is a global challenge. The design and implementation of effective landscape restoration and sustainable land management (SLM) is especially complex because multiple stakeholders with very different interests and priorities are involved. Optimizing the impact of restoration and SLM and reaching win-win solutions requires professionals who can bridge the gaps between ecology and economy, environment and business. However, while there is a clear need for training future practitioners to deal with global challenges as defined in the UN Sustainable Development Goals, such an education is currently lacking.
The ENABLE-consortium is an Erasmus+ co-funded programme that aims at developing a European education platform involving academics, private businesses, public sectors and NGOs. The goal of ENABLE is to raise awareness about the benefits of integrated landscape management based on sustainable business models. The activities of the ENABLE Consortium so far have included the development of a Massive Open Online Course (MOOC) on business approaches to sustainable landscape restoration. ENABLE is also developing a portfolio of teaching cases on various approaches to land restoration in different contexts targeted to business students and practitioners. Another outcome of ENABLE will be the establishment of a Community of Practice (CoP), where participants can exchange knowledge, expertise and contacts on landscape restoration with a business approach. The ENABLE consortium highlights the necessity of multi stakeholder partnerships, holistic thinking, and consideration of 4 returns of restoration (inspiration, social capital, natural capital and financial capital) to accelerate large scale implementation of landscape restoration and sustainable land management.

**P-21**

**Rangeland resources as a life support for human beings, birds, plants and animals**
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The Kingdom of Lesotho has total suface area of about 30 355 square kilometers of which around 60% is estimated to be rangelands, which are primarily used for grazing livestock. Excessive livestock grazing, changes in land use patterns, such as enchroachment of settlements and cultivation in rangelands, excessive livestock numbers and climatic changes such as prolonged winters, droughts and erratic rainfall have intensified pressure on rangelands and have caused extensive land degradation and soil erosion. Lesotho is now described as a site of widespread environmental degradation. This conditions have negatively affected socio-economic, cultural as well as ecological demands, thus threatening people's livelihoods.

In response to the above-mentioned effects of unsustainable range resources management practices, a study on grassland restoration in Lesotho was carried out. The two main objectives of the study were to take a biophysical baseline survey for systematic landscape-level assessment of soil and ecosystem health. Secondly, the study aimed at investigating effects of different intervention measures on degraded rangelands. The study was further aimed at determining appropriate and sustainable guidelines and strategies for rehabilitation and restoration through ecologically sound methods.

The study was carried out by assessing processes of land degradation and effectiveness of rehabilitation measures overtime. The Land Degradation Surveillance Framework (LDSF) was used for measuring indicators of health of ecosystem, including vegetation cover, structure and floristic composition, historic land use, visible signs of soil degradation and soil physical characteristics. Furthermore, rangeland assessments were carried out on rehabilitated sites.

The results showed that Lesotho is faced with severe land degradation, extinction of native flora and fauna, loss of biodiversity and shrubfication. It is therefore important that a healthy and balanced ecosystem is maintained to sustain the biodiversity through reseeding of denuded rangelands, removal of invasive shrub species and proper rangelands and wetlands management

**P-22**

**VEGETATION AND SOIL FERTILITY RESTORATION IN NATURAL AND AGROECOSYSTEMS IN SALIMA, MALAWI**

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Land and forest restoration is influenced by different approaches to land use management. A study was conducted to assess the natural restoration potential for vegetation and soil condition in the three land use types of protected forest area (PFA), harvested woodland (HW) and traditional agriculture (TA) in the Miombo woodlands in Salima Malawi. Data were collected from 42 plots on the number of tree species, diameter at breast height, regenerations and soil properties. The study found that there was significantly ($p < 0.05$) higher tree species diversity and stem density in the HW. The HW and TA showed stable tree populations while the PFA was characterized with an ageing tree population. Regenerations were also significantly higher ($p < 0.05$) in the HW and TA fields than in the PFA. While OM and associated OC was higher in the PFA and HW ($p < 0.05$), there were no statistical differences in levels of phosphorus, potassium and pH across PFA, HW and TA. However, soil physical properties were enhanced in PA and HW with significantly lower ($p < 0.05$) bulk density than in TA fields. The study also found that disturbance in the form of HW and TA contributed to improved species diversity, stem density and increased regenerations for Miombo woodlands. The study concluded that tree diversity may not be achieved in strictly PFA and therefore, recommended that a 'suite' of management measures would be required to balance conservation and promotion of tree diversity. On the other hand, soil fertility levels decreased in the agroecosystem compared to PFA and HW presumably due to continuous cropping. It is therefore recommended that soil improving trees should with high numbers of *Faidherbia albida* and *Philenoptera violacea* species.

**P-23**

**The Mountain forests of Kyrgyzstan in the conditions of climate change, problems and solutions**

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Kyrgyzstan belongs to a region with very limited forest cover. The forests are unevenly distributed throughout the republic. The area of the forest counts only 5.6 % of total area of the country. They fulfill, first of all, the environment-forming and nature protection functions. They are all attributed to the first category of the rating system of the USSR for forest importance, the Fundamentals of Forestry Legislation of the USSR. Therefore, cuttings are only allowed to ensure forest health and restoration.
According to the climatic observations the average annual temperature in the Kyrgyz Republic increased by 0.8°C in the 21st century, the annual rainfall increased by 6%. Beside of that the climate change scenarios indicate an increase in the average annual temperature by 2°C by 2050, compared to the base period from 1960 to 1990. These changes are affecting ecosystems as for example progressive desiccation of slopes and degradation of mountain vegetation. According to reports, over the past 25 years, the boundary of desertification has advanced to the mountains by 500m vertically. Here a whole series of southern semi-desert and desert plants appeared, never

before growing in these areas.
Global warming of the climate, according to expert assessments, will lead to a slight shift in the boundaries of forest belts in Kyrgyzstan up the mountain slopes. It will possibly change the structure of tree and shrub species towards a higher proportion of xeromorphic species.

However, the dynamics of forest ecosystems can be stimulated by establishing forest plantations, taking into account the forest growing conditions and development of measures to promote natural regeneration. To do this, it is necessary to prevent anthropogenic causes of degradation, like: a) intensive and unregulated grazing across the whole forest ecosystem; b) population and livestock growth in mountain areas; c) the increased usage for recreational purposes.

**P-24**

**Fire effects on indigenous tree species in the Guinea savanna: implications for climate change mitigation**
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The indiscriminate burning of vegetation is a common practice in the Guinea Savanna of Ghana. Burning begins at the onset of the dry season (November) and lasts until the end (April). This study investigated the effects of time of burning on tree diversity and density in the study area. A total of 36 (10 m x 10 m) quadrats were randomly demarcated within a three treatments of early and late dry season burning and non-burning study plots at the Mole National Park, Ghana. Samples were taken in the March, a few weeks after the late burning period. Twenty-seven different species belonging to fourteen families were recorded in all the treatments. Most of the species identified belonged to the families *Combretaceae, Fabaceae* and *Leguminoceae*. *Vitellaria paradoxa, Terminalia avicennioides, Combretum adenogonium* and *Combretum molle* were the most common and abundant in all treatments. Late burning plots recorded the lowest diversity amongst the three treatments. Unburnt plots had higher tree density than burnt plots. Early burning treatment recorded more diverse individual species but had the lowest density. Higher tree densities would enhance carbon sequestration. However, ecosystem resilience is also dependent on the diversity of biotic communities among other factors. Sustainable land use practices including protections of trees on farms and prescribed early dry season burns could be an option to contribute to climate change mitigation in the region. Late dry season fires are a threat to tree species populations and should be discouraged

**P-25**

**Climate-induced changes in net primary productivity of savannah-like ecosystems: the mitigating role of scattered trees**
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The increasing aridity due to climate change is considered a major threat for biodiversity conservation and provision of ecosystem services (ES). This is particularly relevant in agroforestry systems such as savannah-like systems (dehesas), which cover vast areas worlwide and provide a range of key ES. However, the drivers and magnitude of climate-induced changes in ecosystem functioning remain poorly understood in these systems. The scattered trees that are present in these landscapes play a relevant role due to the disproportionally large ecological functions they provide relative to the small area they occupy. Nevertheless, there is little consensus regarding their effects on some relevant ecosystem properties such as net primary productivity (NPP). In this study, we experimentally evaluated the impact of the drier and warmer conditions projected by climate change models on NPP and their derived ES (quantity and quality of fodder for livestock) in three dehesas located in south Spain. We harvested all the aboveground biomass produced in a total of 144 plots subjected to four climatic treatments (‘control’, ‘warming’, ‘drought’ and ‘warming+drought’). These plots were equally distributed in the two most frequent habitats (open grasslands and under the tree canopy). NPP increased in the ´warming` plots and decreased under experimental drought compared to the ´control` treatment. Higher NPP values were also detected in those plots subjected to these two abiotic stressors despite their individual opposing effects on NPP. These trends remained unchanged in both habitat types, but differences between climatic treatments were more marked in those plots located beneath the trees. This suggests that the potential mitigating role of trees as buffers of climate-change effects on ecosystem functioning must be taken cautiously. These results will contribute to better understand the mechanisms underpinning ecosystem potential to deliver relevant services as well as to implement successful restoration plans in future environmental scenarios.

**P-26**

**TERECOVA: Assessing forest restoration actions in Mediterranean lanscapes by organic carbon sequestration**

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Ecological restoration policies and actions have commonly focused on optimizing the short-medium term performance of plant species and plant cover. They have prioritized wood production and biophysical aspects of the combat against desertification, paying less attention to the provision of ecosystem services and global change. According to the strategies developed by the IPCC ARS WG2 and WG3 draft reports, adaptation and mitigation to climate change includes, among other options, increasing carbon sequestration in terrestrial ecosystems. In such a context, ecological restoration is considered as a management option with multiple benefits, because it helps to improve change, adaptation, mitigation and biodiversity.
The general objective of our research is to assess the impact of different restoration scenarios on the provision of ecosystem services, with particular attention to landscape capacity for carbon sequestration. The specific objective is to evaluate short to medium term organic carbon stocks in two selected restoration projects developed in last decades in Mediterranean forests of Vaencia region (E Spain). Restoration techniques included slash brush and planting broadleaved resprouting species in *Pinus pinaster* stands and thinning plus planting with *Quercus faginea* in high density post-fire regenerated *Pinus halepensis* stands.
Preliminary results show that restored forests improve the potential for carbon sequestration due to (1) the initial necromass input produced by slash brush that increases C stock on the topsoil, (2) thinning improves forest growth and subsequent carbon fixation by trees. Furthermore, promoting mixed forests by introducing native resprouting species is expected to increase soil organic carbon in the longterm.
We thank funding received from the Ministry of Economy, Industry and Competitiveness and European Regional Development Funds (FEDER), project 'Tools for planning ecological restoration in the Region of Valencia' (TERECOVA; CGL2014-52714-C2-2-R).

**P-27**

**Ecological restoration and post-mining landscape adapted to climate change impacts: a policy network perspective**

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The Czech Republic has a long tradition of coal mining which is considered to be one of the major anthropogenic drivers of greenhouse gases emissions. Thus, the Czech Republic stands before strategic decision of how quickly and through what means transform its carbon intensive energy industry. Any related policy changes then demand support of political elites as well as target and advocacy groups. This applies also to the post-mining restoration that aims to create valuable ecosystems with prevailingly non-productive functions that are better adapted to climate change impacts. Such complex process requires functional exchange of expert information among various types of organizations ranging from state organizations, through mining, project, and reclamations companies, to research and non-governmental organizations. In this research, we explored prevailing patterns of expert information exchange within and across advocacy coalitions. The data were collected from an online survey of 83 organizations done in the second half of 2017. We found that the Czech lignite-mining policy network is clustered into two coalitions with opposing policy core beliefs: industry coalition and environmental coalition. The expert information exchange strongly overlaps with the identified coalitions and contributes to their cohesion. These results support the interpretation where expert information exchange encourages policy polarization rather than policy learning. The establishment of a policy venue is suggested to facilitate cross-coalition expert information exchange.

**P-28**

**Soil organic matter characterization by thermal analysis to assess the land restoration**

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The success of most restorations depends on the conditions of the new soil. Especially, it is important to know the content and composition of organic matter because this is closely related to biodiversity, C turnover and nutrient cycles. In addition, the quality of the soil organic matter is useful to predict the contribution of soils to the emission of greenhouse gases into the atmosphere.
However, the study of organic matter has a great limitation due to the lack of simple analytical techniques for its study. Different chemical procedures have been developed, but most of them are complex. There are instrumental techniques, but most of them are expensive and not easy to interpret. An alternative to alleviate these methodological drawbacks is thermal analysis (TA). These techniques are much cheaper than other techniques and, in addition, do not require any previous treatment of the samples.
During the presentation, different applications of the calorimetry techniques to land restoration will be discussed: 1)

soil after wildfires: the TA serve to define the degree of soil degradation and therefore, to determine the most appropriate conservation treatments, 2) characterization of organic amendments used for the restoration of agricultural soils and grasslands; and 3) the evolution of organic matter in reforested and abandoned agricultural lands.

**P-29**

**Aboveground and soil carbon sequestration rate in three afforested areas in SW-Iceland**
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Climate change mitigation can be an important environmental service of restored forests and woodlands. Iceland, as other European countries, has a national forest inventory where the data for aboveground carbon sequestration of both native *Betula pubescens* woodlands and managed forests of various native and exotic tree species are collected at a national level. The spatial resolution of such national inventories is, however, insufficient so their data can be used to validate carbon sequestration of individual restoration- or afforestation projects carried out by different NGOs, municipalises, companies or private land owners; who frequently are interested in obtaining such data for their lands. In the present project we developed a methodology to evaluate temporal changes in carbon stocks both aboveground and belowground for such smaller projects. As a case-study, in collaboration with the power company Reykjavík Energy (Orkuveita Reykjavíkur) and the NGO Reykjavik Forestry Association (Skógræktarfélag Reykjavíkur), we tried the methodology out at three locations in SW Iceland; Nesjavellir, Ölfusvatn and Heiðmörk, where the native *B. pubescens* has both been planted and expanded its coverage by natural regeneration following a grazing exclusion and where some stands of other tree species have also been planted. We will show our results and evaluate if our methodology was successful and able to produce accurate estimates of ecosystem carbon sequestration rates and mitigation potentials for those three smaller areas.

**P-30**

**Assessment of GEST methodology for the GHG flux rates on a large fen complex**
Laimdota Truus, Mati Ilomets, Raimo Pajula
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The aim of the presentation is to evaluate the potential GHG flux rates based on plant cover, water level and peat properties (type, thickness) following the GEST approach. The GEST methodology is based on vegetation reflecting long-term water level and being thus a good proxy for GHG fluxes on drained peatlands. The Estonian site of the project Life Peat Restore is a large calcareous fen complex over 3300 ha in the NW Estonia. There are little GHG emission data, or the data are extrapolated from the other vegetation types in relation to the fen vegetation; in absence for forested peatland sites. GHG emissions are calculated for the Central European climate conditions and do not adjust to these on the northern latitudes.
Plant cover analyses were made on more than 800 plots over the site which covered different habitat types from near-natural open calcareous sedge fen to deeply drained peatland forest. Plant cover and remote sensing (drone photos) analyses allowed to distinguish five GEST habitat types and estimate the share over the site. Also we calculated the biomass of tree layer in different types. In the presentation we would like to evaluate about the potential GHG flux rates by habitat types and over the site and discuss about the needs for regional calibration and gap-filling in the vegetation-flux relationships for the boreal fen habitats.

**P-31**

**Response of water table and vegetation on restoration efforts: case study in a pre-alpine bog.**
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Water table is the major driver for peat conservation and peatland greenhouse gas emissions. In Germany the majority of peatlands has been drained for peat agriculture, forestry and peat cutting. This has led to a change in peat properties and therefore peat hydrology. A few decades ago rewetting of peatlands for conservation started, and lately restoration activities for climate mitigation has increased. For both aims the restoration of a pristine like water levels within the peatland is crucial. However, the spatial water level changes after rewetting are poorly monitored and not yet understood well enough for regional/state wide predictions. To foresee the success of rewetting on a broader scale more detailed data about the behavior of water levels and corresponding vegetation responses in Bavaria is needed. Therefore, we want to monitor 8 different peatlands (4 bogs, 4 fens) in southern Bavaria in a stepwise approach. In this study we focus, as a case study, on a rewetted pre-alpine bog with a relatively small scale dip well net to measure the spatial and seasonal variation of the water level. With a space-for-time approach we can monitor the response to different rewetting actions with different time after rewetting. In the bog, approximately 33 manually measured and 8 automatically measured dip wells were installed in the spring of

2017. Additionally, we installed a weather station, measured the runoff of the major drainage ditches, and monitored vegetation.

**P-32**

**Assessing the condition of the Flow Country peatlands to support their future protection**
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Peatland condition monitoring utilising both field surveys and remote sensing techniques is well established in Scotland. However, each has its associated strengths and weaknesses. Many of these weaknesses can be resolved if a more synergistic approach is considered between the two data collection methodologies. If realised this has great potential for the management and restoration of peatlands at the landscape scale. The aim of the project is to gather data from both in-situ greenhouse gas flux measurements, unmanned aerial vehicle (UAV)-derived imagery and ground motion from ISBAS InSAR to assess peatland condition in a range of settings. Target areas are located within the Flow Country: the largest blanket bog area in Europe. Two sites were selected: a peatland classified to be in good condition - Plantlife Munsary peatlands - and an upland peatland in a degraded state, at RSPB Knockfin Heights. Sites are surveyed at monthly intervals over the growing season with gas flux, UAV and InSAR measurements. These are supplemented by lower intensity sampling over the winter period to ensure measurements were representative. Measured variables include soil temperature, photosynthetic active radiation (PAR), water table depth and moisture content. Vegetation cover (-change), micro-topographic features and spectral signatures of different plant functional groups are also mapped using field techniques and GIS and remote sensing tools. This set of environmental and topographic parameters are then combined with remote sensing data to upscale the technique over the whole Flow Country. The development of this tool shows great potential in the identification of sites with the greatest potential for restoration within what is Europe's largest area of blanket peatland.

**P-33**

**Restoration of mire habitats in Estonia**
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State Forest Management Centre, TARTU, Estonia

Because of intensive melioration of waterlogged soils in 1950s-1970s, about 70% of mire habitats are considered as degraded in Estonia. Although 69% (229 000 ha) of mires are protected now, the network of ditches still affects the structure and functioning of mire habitats. The target has been set to restore 10 000 ha of mires by 2020.
The restoration of mires aims to raise the water level and to create suitable conditions for the species that live in mires. The past distribution of mire habitats is studied by using old aerial photos. Elevational maps are then used to model the flow routes of water and the most suitable location for the dams.
Before blocking the ditches, the need for forest thinning or clear cutting is considered. If it comes out from the historical data that the location was treeless before melioration, then the tree biomass is removed before restoring the hydrological regime.
The first projects of mire restoration dates back to 2012-2013 in Estonia. Since then the technique of restoration has become more advanced. While the first dams were just small blockages made from wood, massive dams made from peat are built now. Whenever it is possible, the whole ditch is filled with peat additionally to building dams. The water levels in restored mires are monitored at least for five years.

**P-34**

**Hydrology LIFE - conservation of peatlands and small water bodies in Finland**
Tuomas Haapalehto
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Wetlands are biodiversity hotspots and provide many globally important ecosystem services, such as carbon storage and control of water circulation. They are, however, among most threatened habitats in Europe due to extensive human land-use. A 20-year experience on wetland restoration in Finland will now be utilized in Hydrology LIFE project, that safeguards peatlands, small water bodies and important bird lakes in 103 Finnish Natura 2000 areas. The major cause for peatland degradation in Finland is forestry-drainage. The blocking of ditches and removal of trees on 5200 hectares in and around 95 N2000 sites recovers the wet and open habitats crucial for target species. The measures also restore peatland's ability to store water, nutrients and carbon. New methods for simultaneously improving biodiversity conservation and water protection are developed in the project running 2017-2023. Dredging, channelization and drainage are widely decreasing the ability of streams and ponds to sustain their natural communities and control the circulation of water. In the project funded 60% by European Commission we,

therefore, restore 34 km of degraded streams and raise water table in 17 ponds. We also create open water areas and increase the mosaic structure of habitats e.g. by dredging and raising the water table to improve the habitat quality on important bird lakes.
Poor understanding on long-term impacts on restoration is one of the biggest challenges in reaching the huge global targets for ecological restoration. We collect and analyse data-sets covering periods up to 15 yr after restoration to understand the impacts of restoration on vegetation, hydrology and green-house gases. Significant effort is also paid to examining sosio-economic impacts of the project, to developing new monitoring methodology, such as drones, and to disseminating results.

**P-35**

**Year-around Sphagnum growth and its implications for the peatland restoration**
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*Sphagnum* mosses are the key organisms in peatlands that shape the environmental conditions and through the peat formation contribute to the carbon sink function. Their productivity is thus a keystone issue and they are generally considered as the most important species in relation to peatland restoration. Growth rate of several *Sphagnum* species has been studied in the warm season, but the importance of autumnal and winter growth have received much less attention. Therefore, we studied the seasonal distribution of growth, with a particular interest on possible autumnal and winter growth.
We measured the growth in length and biomass of three *Sphagnum* species (*S.angustifolium, S.fuscum, S.magellanicum*) by the crancked wire (n=180) method at three northern European bogs located in Estonia and Finland, with differing climate and magnitude of drainage. Mosses were measured at the end of each season (Sept.2014, Nov.2014, Apr.2015, Sept.2015) to quantify both annual and seasonal growth.
On average, the annual *Sphagnum* growth in length was 20 mm and biomass production 199 g $m^{-2}$. The growth in the autumn and winter constituted roughly 24 and 13% of annual linear growth, and 15 and 6% of production, respectively. *S.angustifolium* had the highest linear growth and *S.fuscum* the highest production across the sites and seasons. Our results thus indicate the ability of Sphagna for year-around growth if the conditions are favourable.
The establishment and development of *Sphagnum* cover is essential for the restoration of drained peatlands. *Sphagnum* cover stabilises moisture and temperature regime on the ground, enabling establishment of other peatland plant species. One likely consequence of climate change in northern latitudes is longer autumns and our results show that this could increase *Sphagnum* growth. This has a potential to enhance the restoration success at drained peatlands. *S.fuscum* is the least affected by freezing and thus potentially suitable for the revegetation.

**P-36**

**Creating Sustainably Wooded Peatland**
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In Scotland large areas of open bog have been planted with commercial forestry plantations. Scotland's forestry regulatory body has recently proposed that some harvested peatland forestry plantations should be converted to a low density non-productive native woodland for biodiversity, carbon and landscape benefits. This is a controversial alternative to either commercial restocking or restoration to open bog. This project looks at how this idea has been interpreted by land managers and identifies relevant research questions based on common concerns about the idea. To achieve this a series of semi-structured interviews were carried out on a range of stakeholders working in peatland and forest management. The project has shown that the biggest concerns are whether these woodlands will provide a seed source for tree regeneration onto adjacent open areas and whether the woodlands will provide the suggested biodiversity and carbon benefits. The project is now investigating these research questions in a number of existing low density wooded peatland sites in Scotland.

**P-37**

**Bog in a Box; is long term peat storage for future restoration viable?**
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Lying at a latitude of 60° north, 180km north of Scotland and 345km west of Norway the Shetland Islands form the northern most reach of the British Isles. They also represent one of the densest areas of peatland cover in the British Isles. In 2010 this presented a problem to the developers of the Shetland Gas Plant (SGP), an onshore natural gas processing plant receiving natural gas from underwater wells to the west of Shetland, as the site chosen involved the excavation of globally rare blanket bog up to four metres deep. Committed to the restoration of the site, currently

projected in 30 years' time, the solution was to store the 672,000m$^3$ of peat excavated during construction in purpose built containers. As one of the first instances of peat storage in this way it is unclear if it will be suitable for use in restoration. The aim of this project, therefore, is to establish the viability of this novel method of peatland storage for future restoration.
It will do so by addressing the following questions; 1) How is the storage of the peat impacting on its chemical and biological functioning and physical properties? 2) How can blanket bog functioning and vegetation be effectively restored after the complete disruption of its hydrophysical structure? 3) What impact has the development of the SGP had on carbon stored within the peat and how does it compare to other peatland developments? Presented are the methods being used to assess these parameters, which will not only allow for us to assess the viability, and potential improvement, of the storage process, but also allow future projects to further reduce their impact on these scarce habitats.

**P-38**

**Science and practice: Sand Martin (Riparia riparia) management in mining areas**
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Sand martin (Riparia riparia) colonies in Europe are primarily located in mining sites. Therefore, they depend critically on the management and rehabilitation of mining areas. Our objective was to understand habitat preferences and reproductive behaviour of sand martins in mining areas, in order to propose management actions to help reconcile mining activity with sand martin breeding. We studied sand martin breeding habitat preferences and reproductive behaviour in mining areas in central Spain in 2017. This was done at three scales: colony, subcolony and burrow. At colony scale, sand martin presence and abundance depended positively on the age of the mining sites and the annual mean temperature of the area. The number of burrows of the colony was negatively influenced by the distance to water, and varied with the type of extractive industry (cement and aggregate production in quarries and sand pits) and the age of the site. At subcolony scale, abundance of sand martins varied between vertical extraction faces, stockpiles and spoil heaps, their orientation and their age, preferring warmer orientations and more recent faces. The number of burrows of the subcolonies positively depended on the vegetation cover of the vertical surface. At burrow scale, the slope was the most relevant factor determining burrow location. Regarding reproductive behaviour, we found high phenological desynchronization between colonies and different subcolonies at each colony. We conclude that management actions for sand martins should consider the habitat preferences shown at each scale, and they should take into consideration the desynchronization between the breeding pairs by extending the actions for the entire duration of the sand martin's breeding period. Management will also require decisions at short, medium and long term, incorporating yearly information.

**P-39**

**Making hydropower more environmentally sustainable - learnings from Norway**
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HVL, SOGNDAL, Norway

Hydropower development increases globally, particularly since it is regarded a key measure in climate change mitigations, and crucial for sustainable development. However, renewable energies, including hydropower, also come at a price. Hydropower degrades nature through regulation of watercourses, but also through building of infrastructure and various encroachments. To meet Aichi target 15 (restoration of >15% of degraded ecosystems before 2020), further hydropower development must include knowledge-based restoration measures. Lessons on how to balance hydropower benefits and disadvantages can be learned from countries with a long history of hydropower development due to natural assets. In mountainous and precipitation rich Norway, modest hydropower projects were launched more than 100 years back in time, but through the post-war period of technology optimism, they grew larger. In the 1960s, the emerging environmentalist movement raised critics and resistance against nature degradation, and differing opinions on the value of wild versus degraded and restored nature manifested. Norwegian Water Resources and Energy Administration (NVE) then established a nature conservation office that had a crucial function up to the 1980ies, when large hydropower development ended. The office, represented by an influential officer, introduced "living nature" as a restoration goal. It partly appears valid also today, although insights from restoration ecology suggest that some implemented measures are counterproductive and unsuitable. We offer alternative restoration recommendations appropriate for restoring areas degraded by hydropower related encroachments, particularly relevant for projects launched under harsh, alpine climate.

**P-40**

**Where is biodiversity heading after restoration of spoil heaps?**
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The aim of contribution is to compare the plant composition of post-mining areas such as mine spoil heaps which is developing by spontaneous succession, and with using of reclamation approach. In Central Slovakia, with the rich mining history, we examined two Cu-heaps and one Hg-heap. Data on plant species composition were sampled in 2015 - 2017. Cu-heap Podlipa (with 111 taxa of vascular plants in 11 habitats) is without human interference, Cu-heap Piesky (156 taxa in 11 habitats) has undergone partial reclamation treatments using of the sewage sludge from water treatment and Hg-heap Veľká studňa (335 taxa in 20 habitats) was partially reclaimed by terrain corrections and loading of new soil layer. Each spoil heap was evaluated in terms of its species richness, index of diversity and the representation of invasive species, synanthrophytes and native non-apophytes. This representation is based both on their numbers and abundance and its ratio towards all taxa abundance. The species richness is reflected in several indicators, which we have called indexes of synanthropisation and naturalness of the vegetation composition, as well as indexes of invasive taxa and native-non apophytes proportion.
The study confirm that synanthropisation of the vegetation and occurrence of invasive and native non-apophytes species are higher in more eutrophic and less acidic soils on spoil heaps after the reclamation process.
The work was supported by grant VEGA 2/0040/17.

**P-41**

**Evaluation of different roadside restoration treatments.**
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Regarding the ever-expanding infrastructure, ecological restoration of all kinds of construction projects is getting increased attention, focusing especially on reclamation and restoration of native communities, maintaining biodiversity and enriching landscape aesthetics. The Icelandic Road Administration is placing increasing emphasis on different approaches of roadside restoration. Until recently, soil stabilization was the main concern, using conventional grass seed mixtures and fertilizer. Newer approaches applied by the Icelandic Road Administration, the National Power Company and ON Power Company in Iceland include salvaging and using topsoil for revegetation and transfer of whole turfs of native sward from areas about to be disturbed to road verges or mining areas.
The results of implementing these methods are still unclear, although some good results are already showing at geothermal power plant at Hellisheiði. Evaluating and contrasting the outcomes of the different revegetation approaches is essential for successful future application. Since this has not been done systematically so far, there is a need for easily adaptable methodology for such evaluations.
As part of the “VegVist program” at the Agricultural University of Iceland, funded by the Icelandic Road and Coastal Administration, we have been assessing different monitoring methods and evaluating the visual impact and the ecological outcomes of three different restoration treatments. The aim is to develop efficient protocols for monitoring roadside restoration and improve site-specific knowledge. The main assessing methods for evaluation of ecological outcome tested so far are cover estimate, line-point intercept and line-intercept. For the visual evaluation, we measured surface roughness and will be using environmental photo-monitoring as well. Each method has its own strengths and weaknesses and it is clear that the choice of methods will depend on the final aims and objectives of the evaluation.

**P-42**

**Restoring or not abandoned quarries: it may depends on stakeholder's point of view**
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Whether we should intervene or not on abandoned anthropogenic ecosystem remains a central question in restoration ecology. Answers to this question may differ from the stakeholder’s point of view. Integrating these points of view when monitoring different options that had been carried out decades ago (actively restoring or not) could provide a basis for the future choices. We focused on abandoned quarries in the South-East of France (La Crau area, a Mediterranean steppe ecosystem). Some of them have been partially refilled with the steppe topsoil, some refilled with exogenous soils and some not refilled at all. Our study will focus on the question: which of the different abandonment options provided the best restoration success? Many characteristics have been measured on these systems, such as the plant communities, the presence of amphibians and birds or the soil characteristics. Based on a sociological study we also have some indicators of stakeholder’s perceptions of the different ecosystems that could develop there. Our study will use the ASPIRE framework: Appraising the Success of Project In ecological Restoration and Ecological engineering, which allow the summarization of a whole project success through all its dimensions or objectives. It has been specifically developed to integrate the point of view of different stakeholders. The framework is hierarchized in three levels: the variables, the objectives and the project. The ultimate score of the

project is a weighted mean of objectives scores; the objectives scores are weighted means of their variables scores and the variables scores are calculated through a utility function based on the variables values relative to their references. While the success scores are calculated on the same data provided by monitoring, as each stakeholder gives a weight to the different objectives, ASPIRE is able to provide a success score for each stakeholders.

**P-43**

**Construction and online provision of a SQL database about riverbanks restoration operations with bioengineering techniques**

Delphine Jaymond, André Evette, Frédéric Bray, André Torre, Vincent Breton
Irstea Grenoble, SAINT MARTIN D'HERES, France

Riverbanks form edges between aquatic and terrestrial habitats. They fulfil numerous important ecological functions and services. Natural riparian habitats are known for their great biodiversity, which is extremely high in comparison with their relative area. However, land pressure and building constructions are often built close to the water. Riverbank protection works with bioengineering techniques can be a compromise both for protecting human issues and preserving some riparian biodiversity and ecological services. But the lack of knowledge and experience collection is one of the main obstacles to bioengineering techniques development.
Therefore, the building of a database about bioengineering for riverbank protection could offer an experience collection for both practitioners and scientists. River managers will have the possibility to know what bank protections already exist in their neighbourhood. In this way, they can use this knowledge and the feedbacks to develop new riverbank protection works. For research, it would allow scientists to improve their knowledge through a large set of data including temporal evolution and mechanical resistance of bioengineering techniques.
Information is assembled in six groups: about the work itself (e.g. localisation, riverbank features), the watercourse (about the section in front of the bioengineering work), the soil bioengineering techniques, the origin of the data (which institute, which project), the plant species and a description of the different visits (including the present condition of the techniques).
We are developing a prototype of BDGeniVeg this year. We worked with others specialities like hydraulic and IT in order to determine fields of the database. We complete it with field sampling and bibliographic research. BDGeniVeg is available on a website about bioengineering (https://genibiodiv.irstea.fr/).

**P-44**

**Effects of mitigation measures on biodiversity in road construction in Norway. - An interdisciplinary approach.**

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Increasing road development leads to an increase in negative impacts of road systems on biodiversity, with habitat fragmentation as a main consequence and main cause of biodiversity loss. The overarching topic of this PhD-project is the mitigation hierarchy, and the need to address mitigation measures in road construction more broadly to deliver applied knowledge for management and operators. This includes both restoration of vegetation communities along roads as well as construction of wildlife crossings structures. In Norway, the road administration uses several mitigation measures, but the effect on biodiversity is not evaluated. The aim of this study is to improve evaluation routines. First, we will test landscape functionality by quantifying the importance of landscape elements for wildlife connectivity, resulting in a habitat functionality map. Then we add existing wildlife crossings to the map to investigate the effect on connectivity of existing crossing structures and the cost-benefit balance of building different crossing structures. In the second part we focus on mitigation measures for vegetation in road construction, comparing different vegetation measures along roads and on wildlife crossings. We will investigate the status of plant biodiversity, invasive species and red list species. This gives valuable knowledge on how restoration measures function to achieve a target community and maintain or facilitate biodiversity. The third part of the study evaluates the relative importance of landscape structures, wildlife density and crossing characteristics on the success of wildlife crossing structures, based on results from the first two parts, but also on GPS data and wildlife camera pictures. This applied approach combines lessons from the two preceding parts with the aim of giving advice to road administrations on how to build mitigation measures in an efficient way, and to plan the design of wildlife crossings which function for wildlife and ensure that other biodiversity targets are met.

**P-45**

**Amending soils in post-mining restoration to buffer against changing climates in arid systems**

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Severe soil infertility, along with high temperatures and low annual rainfall, are dominant constraints on the restoration of degraded arid landscapes. With 20% of arid and semi-arid drylands degraded and estimates of 12

million ha of land degrading each year, this issue is of global importance. Furthermore, in a time when climate variability threatens the sustainability and productivity of these arid ecosystems, development of effective strategies to recover and protect soil resources and biota is crucial for the future survival of these landscapes. In the semi-arid Pilbara region of Western Australia, climatic projections suggest reductions in annual rainfall and high unpredictability of rain events. However, as these ancient landscapes are already degraded due to weathering and mining activities, the restoration of this land is severely challenged. Here, we present a case study on two plant species native to the Pilbara region that examines the effect of inorganic soil amendments, gypsum and urea, on plant growth and soil recovery under multiple rainfall scenarios. The aim of this study was to assess the effectiveness of inorganic soil amendments to (1) promote soil recovery and plant growth, and (2) mitigate the effects of reduced rainfall on soil quality and plant growth. Through an extensive glasshouse experiment, two doses of inorganic amendments were tested against unamended mining waste. Our results show that the addition of urea (nitrogen-based fertiliser) increased plant growth compared to unamended soil substrates when grown under the higher watering regime but this effect was not seen in the lower water regime. Overall, this study contributes to unravelling how inorganic amendments may be used to mitigate the implications of climate change in the context of post-mining restoration in arid regions.

**P-46**

**From research to academic education in Restoration Ecology: salmonids river restoration and other target ecosystems**

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The French group in Restoration Ecology (REVER) has promoted the disciplinary in the direction of students (mainly at Master and PhD levels) since the beginning of its existence. However, there is no Master in France proposing formations entitled “Restoration Ecology” (RE) or entirely devoted to “Ecological Restoration”. Some master is giving lectures, practical design, etc., in RE into a broader offer in Ecology. We explore data of the master in Britany & Pays de La Loire, at the Agronomic faculty of Angers-Rennes (Agrocampus Ouest). Here we evaluate between 2008 & 18 the master thesis contents related to RE, the proportion of lectures in the discipline, etc.… Also two pedagogic experimentations, (i) the participation of Master students in congress in Restoration Ecology, (ii) the new Interreg cross-Channel SAMARCH project on his innovative side, linking research & management & education on Salmon River studies, are evaluated. We analyse the different thematic of their proposal into RE by analysing the titles and abstracts of the production implicating master students, but also the type of lectures, training given during the formations. We discuss the relation between the research groups and stakeholders and managers groups linked to the academic formation and the proposal throughout the analysis of their respective equilibrium. As we started most of the innovations around river restoration projects, we discuss now how to balance our proposal with other ecosystems. The perspective is to enlarge this type of analyses to other research & academic groups in France and Europe. Later, we can imagine that this analyse could contribute to a construction of a net or a European Master in Restoration Ecology.

**P-47**

**Obstacles to restoration: fragmentation of Europe's rivers**

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Rivers are some of the most threatened ecosystems in the world and a major focus of restoration programmes in Europe and elsewhere. A major challenge to achieving good ecological status, as required under the EU Water Framework Directive, is the reduction of fragmentation of river habitats caused by many thousands of barriers. Strikingly, the real number and location of barriers in Europe is, currently, unknown. Extrapolation from detailed national and regional surveys suggest there may be as many as 1 barrier for every 2 river km. In that context the H2020 AMBER project addresses the issue of river fragmentation in European rivers and seeks to apply adaptive management of barriers at multiple scales to achieve more efficient restoration of river connectivity. AMBER is building the first pan-European database of all existing barriers across Europe, collating and harmonising existing institutional data at national and regional scales.
We present here the most up-to-date database on the distribution, typology and drivers of river fragmentation at the pan-European scale. From the 48 national and regional barrier databases collated, >260,000 barriers were identified. Of these, 60% of barriers could be attributed to one of six common barrier types whilst the remaining 40% were of unknown type; 62% were without height attributes; <30% were without barrier, river or basin name and only 7% included information about installed fish passes. We integrate this new information with pan-European datasets

on climate, geography and socio-economic data to derive meaningful drivers of barrier density. From which barrier distribution can be inferred in countries and regions where data is scarce.
This approach allows the generation of a more realistic picture of river fragmentation at the national and European scale with regards to impacts on sediment, water and biota connectivity. Providing an important basis for informing future barrier monitoring and adaptive management.

**P-48**

**Coupled changes in ecological quality and social perception across passively restored rivers in rural landscapes**

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Social dimension is a critical element of river management and ecological restoration success. Positive public perception of restoration activities can facilitate landowner's involvement and catalyze the recognition of ecological improvement. Laypersons tend to associate 'good looking' natural sites with ecological health, which in turn can facilitate the adoption of such strategies. Likewise, managers will likely adopt ecologically correct measures if they tend to be perceived as aesthetically pleasing, as well. This study aims to contrast changes in ecological condition and aesthetic perception in rivers managed under Passive Ecological Restoration approaches in different rural landscapes (France – Normandy, and Portugal – Alentejo). Ecological indicators obtained from floristic relevés were used to assess riparian condition and ecological quality of the sites along the restoration process. Aesthetic perception indicators were collected in an inquiry form, using photos of different stages of restoration and from both countries, which were scored according the principles of semantic differential approach and later analysed using univariate statistical analysis.The society responses to the changes observed on riparian ecosystem as a result of passive ecological restoration trajectory were analyzed across different landscapes and across stakeholders (environmental sciences students, managers/landowners) in Portugal and France. Preliminary results indicate first that ecological condition changes are not linearly related to stakeholder perceptions. Second, experience and cultural background affects perception of ecological condition across different stakeholders. Effective communication and stakeholder engagement is essential for clarifying aims and assure success of ecological restoration.

**P-49**

**Effects of climate change on the hydrological regimes of floodplains along the Naryn River, Kyrgyzstan**

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Floodplain areas of Naryn River in Kyrgyzstan are heavily used by nearby communities. They carry out multi-functional services as pasture land, forest, habitats of plant and animal species, also as resting place and aesthetic landscape. As a result of it, these areas are severely degraded and water erosion is increased, in addition, excessive cutting of forests and grazing were observed. Due to the hydrological disturbance of the floodplains the water erosion cases are caused frequently washing out the riverbanks. Unstable coast alters the movement of water in the river and leads to wandering and also increases the flooding risk. To understand the impact of land use and hydrological changes on the river channel and the floodplain it is important to have a clear depiction of current geomorphological processes. Increasing the roughness and accumulation of sediments on the surface of the floodplain it is beneficial to the uniformly distribution of river flow.
To study the hydrological regimes, there were selected two investigation areas in the distance and nearby of settlements, in case Emgek-Talaa and Ak-Tal villages of Naryn region. The climatic conditions for the investigated area, as well as in the magnitude and frequency of annual, monthly and daily water discharge of surface runoff, and also groundwater level of the Naryn River were investigated. Satellite images were used to study the landscape changes for mapping of the investigation areas. Mapped inundation patterns for extreme flood event and transverse profile for the floodplain area. The river channel migration was analyzed based on Landsat MSS, TM and OLI imagery for the 1972s and 2015. The assessment of changes is necessary for further developing floodplain restoration plans. The study results provide information on options for management and assistance to the local authorities in the integrated management of natural resources.

**P-50**

**Improvement and sustainable management of river corridors in the Iberian Atlantic Region**

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In the Iberian Atlantic Region, there are several landscape change processes (changes in the land use, presence of invasive species, activities regarding public use, intensification of agricultural and livestock farming, climate change) and phytosanitary problems (alder diseases caused by *Phytophthora* ssp.) that, currently, are threat factors of river corridor habitats. These factors are deteriorating and fragmenting them, and having a relevant impact on their functionality.
The LIFE Fluvial project aims to mitigate these consequences, to improve the conservation status and to develop sustainable management measures of river and fluvio-estuarine corridors. Selected areas in the project are Natura 2000 sites belonging to several river basins located in the northwest of the Iberian Peninsula (Spain and Portugal).
To this aim, LIFE Fluvial has designed the following actions:
A detailed analysis of the current status and implementation of a trans-national model for the sustainable management of river corridors to reduce the negative impact caused by the threats and to avoid their spread towards other UE territories.
Design and implementation of restoration projects to improve conservation *status* of the natural habitats of interest, connectivity and to reduce fragmentation.
Control of invasive flora species that pose a threat to the conservation of river corridors, and improvement of their phytosanitary state by removing trees infected by *Phytophthora*
Dissemination of the environmental relevance of river corridors and social awareness in terms of socioeconomic benefits and ecosystem services provided.
Improvement of training/education and technical empowerment of the stakeholders involved in the management and conservation of river corridors.
The project lasts four years (2017-2021) and includes a system to monitor the impact of the actions on habitats and ecosystem services provided by river corridors.

**P-51**

**ECOSYSTEM SERVICES RESTORATION IN THE ERA OF CLIMATE CHANGE: SAND DUNE SERVICES**
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Nowadays, human societies have to tackle severe environmental threats, mainly due to the effect of their own activities such as land use change, pollution, introduction of alien species, atmospheric $CO_2$ increment and loss of biodiversity. Ecosystem restoration has a high potential in order to mitigate and adapt to these threats. Here we present the sand-dune restoration project on the Bay of Plentzia (Bizkaia, Basque Country, northern Iberian peninsula). The bay was highly transformed at the beginning of the XX century reclaiming land to the bay. This led to a reduction of beach area and continues works in order to rebuild storm damage: broken walls and road and sand movements. The restoration project started in 2009 knocking down two buildings, a car park and a road, taking away all the debris, thus allowing the natural substrate, namely sand, to be recolonized by species. The methodology used was mainly based on nature succession, as after planting some species such as of *Ammophila arenaria, Elymus farctus, Festuca juncifolia* and *Pancratium maritimum* the restoration process was left to develop on its own. Within this area a wooden walking path for pedestrians was built, and the sand dunes were restored. By 2016, the sand dunes were highly functional, having achieved an ecosystem structure similar to other sand-dune ecosystems and its resilience, and providing ecosystem services to the society. Since then, the bay is more resilient to sea and storm effects (not having reported storm-damage described), more recreational area is available for the public (such as beach and walking pleasant sites) and sand-dune species diversity has increase in the area.

**P-52**

**Key concepts for ecological restoration in the deep-sea**
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The Society of Ecological Restoration has recently updated the international standards for the practice of ecological restoration, including principles and six key concepts. The aim of this document was to “provide support for the technical application of ecological restoration across geographic and ecological areas (whether terrestrial, freshwater, coastal or marine) to improve biodiversity conservation outcomes for all ecosystems, secure the delivery of ecosystem services, ensure projects are integrated with socio-cultural needs and realities, and contribute to the 2030 Agenda for Sustainable Development. In this talk we will present work carried out under the MERCES project and in particular we will discuss how analogues from terrestrial restoration and findings from shallower water restoration work can be used to evaluate concepts and form guidelines for ecological restoration of the deep-sea ecosystems. We will discuss the challenges posed to describing local native reference ecosystem and identifying

and measuring key attributes in the deep-sea using four case studies, requiring different degrees of intervention to assist their natural recovery processes. We will also discuss knowledge gaps, time scales, uncertainties and challenges to deep sea restoration

**P-53**

**Ranking Natura 2000 habitats and Natura 2000 areas for nature management and restoration in Finland**
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Reaching the global conservation and restoration goals provides a huge task. The aim to restore 15% of the degraded ecosystems may yet prove to be too ambitious, but it has worked as a catalyst for finding effective overall solutions to approach this task. Here we provide an example of cost-effective allocation of ecosystem improvement resources within the network of protected Natura 2000 areas in Finland. In our ecosystem restoration and management prioritization approach we ranked 1 541 Finnish Natura 2000 areas based on their potential for cost-effective ecosystem improvement. We applied Zonation spatial planning method and software to prioritize the Natura 2000 areas according to their ecological value, while considering factors like complementarity (irreplaceability), condition (state of the ecosystem patch), connectivity, and cost of the overall solution. We used biodiversity data (GIS: location and current state of 67 N2000 habitats and threatened species) and expert knowledge of improvement methods, effects and costs. In addition to identifying high priority areas on maps, the systematic analysis method offers quantitative measures to investigate the trade-offs related to complex conservation decision making processes. Results of the analyses are currently used in real-life planning processes by the Parks and Wildlife Finland, governing the protected Natura 2000 areas in Finland.

**P-54**

**The RestHAlp project: ecological restoration of habitats in the Alps**
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Alpine habitats are particularly susceptible to degradation as a result of different factors. Human activities and the diffusion of Invasive Alien Species (IAS) in vulnerable areas contribute to the loss of plant biodiversity, endangering many of the goods and services provided by mountain ecosystems. Here we present the Interreg ALCOTRA project RestHAlp "Ecological restoration of habitats in the Alps", aiming at i) restoring degraded habitats in Sites of Community Importance (SCIs); ii) limiting the spread of IAS in alpine valleys; iii) involving the population in the conservation of habitats.
To address these challenges, a partnership of SCIs managers and research centers is carrying out a set of actions in Aosta Valley (I), Savoie, Isère and Hautes-Alpes (F):
- use of an evaluation method to define restoration objectives;
- use of native seed mixtures to restore degraded habitats and dissemination of the results;
- production of a prototype machine for the large-scale harvesting of native seed mixtures for preservation;
- characterization by DNA analysis of local populations of plant species;
- equipment of wetlands to quantify their hydrological and socio-economic functions and assess their ecosystem services;
- monitoring of IAS through a participatory science approach and analysis of their diffusion dynamics.
Main outcomes of the project will be: demonstration sites of ecological restoration of habitats both in French and Italian SCIs and a guide of good practices; maps of source areas for the collection of preservation mixtures; a prototype machine for the large-scale harvesting of native seeds; distribution maps of the most harmful IAS in the territories concerned and a dynamic IAS surveillance system, including a smartphone application and a database; demonstration sites and a methodological guide for assessing and promoting ecosystem services.

**P-55**

**Blütenhöfe21 / Floweryards21: A Church District for Biodiversity**
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Evangelical Lutheran Church District of Rendsburg-Eckernförde, RENDSBURG, Germany

Caring for current and future generations, and experiences of healing and redemption are powerful components of religion - and of ecological restoration. Religious groups across the globe are increasingly aware of man's role in

climate change and environmental degradation, assuming responsibility and taking action. One such action is outlined here. Incentives for the project: 1) The Evangelical Lutheran Church of Northern Germany made a pledge to mitigate climate change, through reduction of greenhouse gas emission to zero by 2050. However, climate change is happening and must be adapted to. High species and population diversity can promote adaptation. 2) The percentage of unused area in churchyards and graveyards is increasing due to changes in sepulchral culture, sometimes combined with membership decline and tightened budgets. 3) Public support of wildflower planting schemes is high, boosted by recent alerts to a dramatic decline in insect populations in Germany and Europe. Participants: Church communities of our district, managed by employees and volunteers. Goals: 1) To seed and plant species-rich meadows and margins, in half of church-owned yards over the next two years. 2) To establish ecologically and economically sound management. 3) To engage local communities, and to foster integration of environmental restoration and protection into spiritual and practical church work.

**P-56**

**How do ant communities and ant-seed interactions respond to passive restoration in the Montado?**
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Passive restoration, via grazing exclusion, is a common practice in the Montado, a cork oak ecosystem extending in south-west Europe. Grazing exclusion benefits economic important tree species, and key-biodiversity groups, as ants, while favoring the recovery of the ecosystem from invasive species, which have been often associated to livestock presence. First, we evaluated effects of low intensity grazing (control) and of passive restoration along a chronosequence of grazing exclusion, where grazing was excluded for 8, 12 and 18 years, on ant community composition, including ant functional structure, based on the community-weighted mean. Second, we will evaluate ant-seed interaction and seed dispersion in the oldest restored site (18 years) and in the control site, where the invasive Argentine ant species is reported. We aim to analyze ant-seed interaction under a functional perspective, linking seed and ant functional traits in the two sampling sites. Results on ant community composition showed that the oldest restored site was the only one with a stable and recovered ant community. The invasive Argentine ant was absent from the 18 years old restored site, while being the only ant species recorded in the control site, hence to understand effects of passive restoration on ant communities, its presence needs to be taken into account. A longer restoration time, as for the 18 years excluded site, seems to favor ant community recover and the re-establishment of specific functional groups, which may outcompete and exclude the invasive ant species, whereas a longer restoration time might be needed for the 8 and 12 years restored plots, to recover from grazing and the Argentine ant. Given these results, we expect a broader number and more heterogeneous range in ant-seed interactions in the oldest restored site compared to the control site, hence a higher potential in seed dispersal in restored sites.

**P-57**

**Ant hills as islands in a sea of temperate pasture**
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Ants play significant role in vegetation. Among others, their nests provide microsites with different soil conditions potentially suitable for seedling recruitment in competitive communities as temperate grasslands and dispersal to specialized plants (myrmecochory).
We compared the functional traits, species and functional diversity as well as seedling recruitment of persistent ant hills with surrounding vegetation using paired plot design. One plot of the pair was located in an ant hill and the other in adjacent vegetation (control plot). Both plots had identical size determined by the size of the ant hill. The study was carried out in a mesophilous pasture dominated by grasses Agrostis capillaris, Festuca rubra and Holcus mollis with nine ant species (dominant Lasius flavus).
Ant hills differed significantly in composition of both established vegetation and recruiting seedlings. Seedlings were generally more abundant on ant hills, which are also in total less similar to each other in species composition. Small ant hills (~100 $cm^2$) host slightly more species than control plots of the same size. However, for large ant hills (up to 4000 $cm^2$) the species richness was the same. Further, functional diversity of ant hills is higher (Rao index for leaf-seed-heigh). Whereas competitively weak species Arenaria serpyllifolia and Rumex acetosella were more frequent in ant hills than control plots, myrmecochorous plants did not show unified trend. The within species differences in SLA and plant high were not significant i. e. the plant performance on ant hills is not decreased.
Ant hills differed in their plant species composition from the vegetation matrix and were also more heterogeneous; therefore they serve as diversity enrichment islands in relatively uniform temperate pastures.

**P-58**

**Designing habitat networks for Siberian flying squirrel (Pteromys volans) in Estonian state forest**
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Once widely distributed across whole Estonia, the population of Siberian flying squirrel has remarkably diminished during the last fifty years. Currently, only 30-40 nesting sites are known in the north-eastern part of Estonia. The accelerated rate of habitat fragmentation due to intensive lumbering is the main cause of such a dramatic decline of Siberian flying squirrel population in Estonia. Now, the Siberian flying squirrel is considered as vulnerable to extinction in Estonia.
Being an arboreal species, the Siberian flying squirrel is not able to cross forest clearings wider than 100 m. It nests in tree hollows and, thus, needs old forests. In conditions of extensive forestry, both the number of suitable habitats and the coherence of forest habitats decline.
In 2013, Estonian State Forest Management Centre decided to establish corridors between known core areas of Siberian flying squirrel. The following principles were considered:
The corridors must be at least 100 m wide;
No fragmentation of the corridors is allowed;
Within the corridors, there must be forest stands with aspen (at least 15% in stand composition) and bilberry after every 400 m;
In every 1.5-2 km, the corridors must include forest patches (with an area of 5-7 ha) that could be used as temporal habitats by the squirrel – a resting site;
In the corridors, the forest management must assure the sustainability of aspen stands.
By 2014, the area of corridors was 1513 ha and that of resting sites 94 ha. Resting sites are surveyed annually for the signs of squirrels' presence. The results of the survey indicate that the corridors are used by the Siberian flying squirrel and the habitat network, thus, fulfils its purpose.

**P-59**

**Impacts on Native Pollinators in Response to Commercial Honey Bee Introductions**
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The concern over Colony Collapse Disorder (CCD) in honey bees has prompted governments and the agricultural industry to explore ways to combat CCD and protect the bee industry within the United States. Though several factors appear to contribute to CCD, one candidate is the occurrence of pesticides on the environment, especially from agricultural lands and urban landscapes. There is increasing pressure to make available government lands for honey production, where pesticide contamination is expected minimal. While honey production on National Forest and other governmental lands has appeal, the impact of introducing large quantities of non-native bees to the native bee community is unknown. Concern about potential negative impacts is highlighted by the fact that many native bees are quite rare and susceptible to possible local and regional extinctions or displacements. Negative impacts to native bee populations by honey bees is well documented in literature. In addition, the potential reduction in native bee abundance and/or richness due to resource competition has the potential for the spread of bee disease. Loss of native bees may also negatively impact endemic plant populations that have floral structures and pollinator relationships specific to a native bee species. This research highlights an investigation underway to create a baseline inventory of the native bee population within the tall forb communities of the Wasatch Plateau. Beginning summer 2018 honeybees will be introduced to half of these sites and monitored for a minimum of two years to assess impacts on native pollinator communities.

**P-60**

**The role of light in the adaptation of Thymus praecox Opiz to diverse habitat conditions**
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*Thymus praecox* Opiz belongs to thermophilic and heliophilic species, therefore the availability of the right amount of light is an essential factor for its survival in natural conditions. This species is on the "*Polish Red Book of Plants*" with the category CR - critically endangered and the "*Red list of vascular plants in Poland*" with category E - dying out, critically endangered. On the only area, outside the mountains, in the Ojców National Park (Southern Poland), factor threatening its existence is a succession forest and scrub vegetation.
The aim of the study was to investigate the impact of light intensity on the adaptive abilities of the creeping thyme photosynthetic apparatus in the karst valley of the Ojców National Park (ONP). The plant material was taken from two stands, differing in light conditions. There are evidenced by changes in photosynthetic activity, registered by measurements of chlorophyll *a* and *b* content and the chlorophyll *a* fluorescence. The chlorophyll *a* and *b* content was lower in the *T. praecox* leaves growing in sunny stand, compared to the shaded stand. On sunny stand, the photosynthetic activity of plants was lower relative to those growing in the shade. Knowledge of issues related to the physiological of *T. praecox* is a positive prognosis towards the possibility of cultivating this species under controlled conditions. This may be an additional security the existence of creeping thyme in the natural environment, especially in the ONP.
The work was supported by grant Vega 2/0040/17.

**P-61**

**Restoration of secondary grasslands threatened by the shrub species colonization**

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The secondary grasslands are semi-natural habitats whose maintenance depends on human activities. They are extremely rich in biodiversity and therefore the European Union recognizes their importance by distinguishing different habitats to be protected and conserved (Habitats directive). Among the habitats of priority conservation in Italy, the 6210 habitat is the most extensive even though its extension has recently undergone a strong shrinkage. Indeed, the reduction of traditional agro-pastoral activities primes the dynamic processes of vegetation recovery that lead shrub and arboreal formations to replace these grasslands. In this context, habitat restoration activities are necessary in order to conserve this habitat.
Here, we present the results of shrub species control and removal activities carried out in 2009 in grasslands of a sector of the Apennines (central Italy) with different levels of shrub cover.
The surveys before the intervention and the post-intervention monitoring (for a total of 9 years activity) allowed us to evaluate the effectiveness of the restoration operation in relation to the different ecological conditions by assessing the recovery of the typical species of the grassland and identifying the most dynamic species with higher growth rate.
In particularly critical conditions it would have been useful to facilitate the recovery of herbaceous species, especially grasses, through sowing. However, this was not possible due to the absence in the local trade of autochthonous seeds. Therefore, the collection on site of autochthonous germplasm of some herbaceous species with high pabular value (*Bromus erectus*, *Cynosurus cristatus* and *Phleum bertolonii*) was started. Germination tests at different temperatures were carried out on the seeds of these species in order to identify the best strategies for their use for conservation and production purposes in relation to the different ecological conditions.

**P-62**

**Introducing genomics in restoration ecology: How many seed zones does Carex bigelowii have in Norway?**

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The introduction of genomic methods in restoration biology is lifted up as a very promising tool for achieving restoration goals. However, there are few case studies showing how these tools can be implemented. We are applying so-called RAD-sequencing tools to investigate the number of seed zones in a common sedge in Norway. RAD-sequencing produce thousands of single-nucleotide polymorphisms (SNPs; variation at a base in a specific position in the genome), that can be used to identify genetic structure throughout a species distribution area. The introduction of genomic tools will give enormous amount of data and help us overcome challenges related to older methods.
Seeding is used to accelerate revegetation in restoration project. There are several strategies for selecting seeds, but the goal is often to reintroduce plants that are genetically similar to the historical population of the area and/or introduce genetic variation preventing inbreeding. Molecular methods are used to identify population that matches the genetic variation wanted.
We chose *Carex bigelowii* as our study species as it is a likely candidate for seeding in restoration project in mountain areas in Norway. A previous study, using neutral markers, shows that this species can be divided in two large seed zones, a southern and a northern, in Norway. There are likely two subspecies in Norway, and the separation of southern and northern seed zones could possible reflect the two subspecies. By using genomic tools we are aiming at identifying the two subspecies and their distribution ranges in Norway and investigate whether the two subspecies are genetically structured throughout the distribution range, hence divided in several seed zones. We have collected plants from most of the species distribution range in Norway, and identified the two subspecies based on morphological differences.

**P-63**

**Plant species adaptability trials for restoration of plant communities in harsh environments**

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All wildland ecosystems experience disturbance as a natural and relatively consistent frequent part of its evolution and development. However,when these disturbances exceed the evolutionary norms for the environment, restoration practices may be required to return ecological function to plant communities. Plants used in these restoration practices may be native to these environments, but when ecological thresholds have been breached novel plant materials may be required to return ecological function. This presentation focuses on approaches to plant material trials of novel species that may be considered for use in harsh environments with examples from

North America, South America, and Asia. Consideration of plant materials, seedbed preparation and seeding strategies will be discussed.

**P-64**

**Deriving chlorophyll content of induced biological soil crusts from surface reflectance measurements**
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Chlorophyll concentration is a well-proven proxy of biocrust biomass and development that has been commonly used to assess the success of biocrust rehabilitation tasks. However, laboratory methods for chlorophyll analysis require destructive sampling and are expensive and time consuming. Therefore, its applicability is limited to punctual measurements that may not represent inherent spatial and temporal variability of induced biocrust communities in large-scale restoration projects. Thus, alternative indirect methodologies which avoid alterations of surfaces of interest and can be applied at larger scales are required. Indirect estimation of chlorophyll by means of soil surface reflectance analysis has been demonstrated to be an accurate, cheap and quick alternative for chlorophyll retrieval in plants. However, its application in biocrust is yet to be harnessed. For this reason, we evaluated the potential of soil surface reflectance measurements for non-destructive chlorophyll quantification of induced biocrusts under laboratory conditions. Our results revealed that, as it was observed in vascular plants, spectral reflectance at both hyper and multispectral resolution can be used to estimate induced biocrust chlorophyll concentration and, therefore, development status. On the other hand, whereas RAW spectral reflectance values did not provide good estimations of biocrust chlorophyll concentration, some widely used spectral transformations that maximize absorption peaks, such as first derivate of reflectance and continuum removal, provide very accurate results. Normalized difference values in the red-edge region and common broadband indices (NDVI, SR, MSR, SAVI and OSAVI) were also very sensitive to changes in chlorophyll concentration of induced cyanobacteria-dominated biocrusts. These findings highlight the feasibility of using spectral information to assess the success of biocrust rehabilitation on assisted restoration activities.

**P-65**

**Cyanobacteria for rangeland restoration in Australian dry-wet tropics**
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Extensive cattle grazing occurs in Australia's dry-wet tropical savanna that covers ~2 million $km^2$, generating annually $14.3 billion revenue and employing 200,000 people. With the global demand for Australian beef rising, pressure on land resources is intensifying. Nearly half of Australia's rangelands are degraded and nutrient levels declining which negatively affects pasture productivity and ecosystem function.
Cyanobacteria link two components of rangeland integrity: protection of soil surface and soil fertility. Microbial biofilms, dominated by cyanobacteria, form gelatinous layers on the soil surface composed of extracellular polysaccharides that bind microbial communities and facilitate their life functions, including biological nitrogen fixation (BNF). Microbial biofilms are integral to preventing soil erosion, aiding water infiltration and maintaining soil fertility.
Microbial biofilms and composition change with different grazing management practices including stocking density and fire interval. We analysed the microbial biofilms on long-term fire and grazing experiments at Kidman Springs Station, Northern Territory. We hypothesised that microbial function would be impacted because disturbance-resistant cyanobacteria would out-compete desirable species capable of BNF, leading to a shift in community structure and function.
To test this hypothesis, we analysed microbial communities with microscopy and DNA sequencing to compare biofilms of unburnt, 2- and 4-yearly burnt grazed sites on two soil types together with long-term grazed sites and grazing exclosures. We focused on nitrogen as a crucial component of rangeland integrity, as common stocking densities of 10 cattle per $km^2$ annually demands ~400 kg N $km^{-2}$ (4 kg $ha^{-1}$). In non-degraded Australian savanna, cyanobacterial biofilms generate ~520 kg of bioavailable N per $km^{-2}$ annually, similar to global estimates of annual BNF-fixation of ~600 kg N $km^{-2}$. Here we present findings in context of knowledge of cyanobacteria in Australia and elsewhere.

**P-66**

**Use of arbuscular mycorrhizal fungi for urban restoration - a roof greening experiment**
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Green roofs provide important ecosystem functions for climate change adaption in urban areas like water retention and temperature regulation. Depending on roof greening techniques and species selection green roofs have the potential to serve as valuable habitat for native dry grassland species as well as for associated flower visiting insects, which both have become rare in rural areas. For standard extensive roof greening, however, plant selection is mostly restricted to non-native and/or cultivated succulents like *Sedum* species. Using native plant species e.g. of dry grasslands for extensive roof greening would probably support regional biodiversity. Most extensive green roofs have been built only with shallow growth substrates limiting their potential as habitat for non-succulent plant species. In addition,artificial standard growth substrates for green roofs are lacking beneficial soil organisms like arbuscular mycorrhizal fungi (AMF), which might improve the drought resistance of introduced species. Therefore, we develop and test methods for soil amendments to increase the habitat function of extensive green roofs for pre-adapted xeromorphic to mesomorphic native plant species of sandy dry grassland in northwest Germany (e.g. *Ornithopus perpusillus*, *Hieracium umbellatum*, *Myosotis discolor*). We are testing assumed benefits of AMF inoculation on the performance and drought resistance of eleven mycophilic native and regionally occurring dry grassland species. We will present results of a full-factorial pot experiment with five replications which started in March 2018 and will end in August 2018.

**P-67**

**P-68**

**Short-term management effects on the Raymond Island grassland after an ecological restoration by hay transfer.**

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Identifying the processes underlying the dynamics of ecosystems under restoration program and assessing their relative importance are fundamental to guide choices and implementing ecological restoration operations (ERO). Once the degradations of the ecosystem are stopped, restoration may be limited by colonization, establishment or persistence of species. In particular, the initial stages of restoration are likely to influence the trajectory of the ecosystem. After a long history of maize culture, an experiment of grassland restoration was set up on a fluvial island (Raymond Island) to test the following hypotheses: 1) the input of plant species propagules and the limitation of competition by plant species already established in the ecosystem should accelerate the very first phases of restoration, 2) the mid-term dynamics of the ecosystem should then depend on the applied management. A restoration by hay transfer was set up in August 2014. Four management methods (initial sheep grazing, delayed sheep grazing, early mowing and late mowing) and a sheep-grazed control without hay transfer, are tested on 40 plots of 100 m² spread over the grassland. Floristic monitoring conducted during spring 2015 and 2017, enabled to highlight a change in the species composition and richness of the plots inoculated by hay, regardless the management method. These changes reflect the first path of restoration trajectory of the restoring grassland towards the donor site for every inoculated modality tested. However, the application of initial grazing management (i.e., sheep grazing allowed immediately after the hay transfer) seems to favour the installation of the introduced species, certainly by alleviating the competition by species initially established on the site. Longer-term monitoring of this ERO will allow us to assess the effects of other management methods that are currently less pronounced.

**P-69**

**Evaluation of seed harvesting methods on 'hay-meadows' (Arrhenatherion and Trisetion communities) in the Iberian Peninsula.**

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Hay meadows are agroecosystems maintained by the secular action of man. Its great botanical and faunal value has been widely recognized and included among the principal habitats to be protected in Europe through the Habitats Directive with codes 6510 (Arrenatherion) and 6520 (Triseton-Polygonum bistortae). However, they are in the process of disappearing in the Iberian Peninsula due to agricultural intensification and abandonment.
The INTERREG SUDOE SOS PRADERAS project, among other measures, tries to develop a method for producing seeds representative of their floristic composition that could be implemented on a larger scale for commercial production.
In order to evaluate possible methods for harvesting seeds, during the summer of 2017, trials were carried out on plots located in Community Interest Sites: (1) Omaña-Luna Biosphere Reserve, (2) Picos de Europa National Parc, in Spain, and (3) Parc National de Pyrenees (France).

We evaluated three methods online with farmers production: a) soil suction after hay harvest, b) seed harvest during hay packing, c) hand sweeper before hay mowing, and another three ad hoc methods for seed harvesting: d) green hay harvesting, e) threshing with threshers for grain harvesting, and f) seed stripping with a pull type seed stripper. The results show all ad hoc methods perform better than online methods. Green hay harvesting, threshing and stripping technique provides 11.2 g/m$^2$, 3.5 g/m$^2$, and 2.0 g/m$^2$, respectively, beside a higher diversity. Sweeper on the first date of harvest was the best of online methods with an average of 0.34 g/m$^2$ seeds. The hoover method harvested on average 0.11 g/m$^2$ and that of the baler, 0.10 g/m$^2$.
These results allow us to conclude that the green hay harvesting is the most productive technique regarding seed production and diversity, although seed striping and on site threshing could be useful for commercial seed production at low cost.

**P-70**

**Seed banks as sources for reintroduction of species: a case study in the Pannonian ecoregion**
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Seed banks gain importance as sources of genetic diversity regarding the need for ecological restoration. We tested the use of seed accessions of the Pannon Seed Bank for reintroduction at an abandoned field in the Hungarian lowland with the aim to restore sandy grassland. Ten native species were seeded in four consecutive years. Seeds were either seeded in the same year as collected or seeded after 1 to 3 years of storage in the seed bank. Our questions were: (1) What are the germination and establishment rate of sown species in the two years after sowing? (2) To what extent is the establishment of sown native species affected by collection year, term of seed storage and sowing time? Seeding success was estimated by seedling counts for two vegetation seasons for each treatment. *Centaurea arenaria* (12%) and *Dianthus serotinus* (8%) had the highest, while *Gypsophila arenaria* (0.12%), *Silene borysthenica* (0.27%) and *Echinops ruthenicus* (0.53%) had the lowest establishment and survival rate. *Festuca vaginata* which was sown as matrix species, resulted only medium establishment rate (1.1%). Among the 4 seeding years, 2013 was the most successful in terms of germination rate and survival, owing to the high amount of precipitation of the next year. Seeds applied in 2011 resulted the lowest success as a result of the serious drought of 2012. The storage of seeds had no significant effect on the reintroduction success. Based on our study the sowing time has the highest influence on restoration outcome through the impact of the weather of the first growing season. Our results support the importance of seed banks as sources of ecological restoration.

**P-71**

**Enhancing biodiversity in vineyards by sowing of native seed mixtures**
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With an annual precipitation of 500 mm, the Saale-Unstrut vine region is one of the driest areas in Germany. Within the course of global warming, a rise of extreme weather events is expected, leading to higher erosion risks as well as to elevated water stress of vine plants. Within the LIFE project ‘Optimizing Ecosystem Services in Viniculture facing Climate Change’ one work package deals with the development of multifunctional seed mixtures for inter-row vegetation.
Two seed mixtures (48 wild plants each) for dry, calcareous sites were compiled, aiming to establish low-growing species that provide copious nectar and pollen sources. The vegetation should ensure erosion control and allow vehicle crossing for vineyard work. In using local ecotypes of wild plants, an optimal adaptation to regional soil and climate conditions is guaranteed. For comparison to the usual practice a commercial ryegrass-white clover-mix was sown with every second inter-rows left open. All mixtures were sown in block design (3 variants, 4 repetitions) in mid-August 2016. Relevés were made on permanent plots once a year in 2016 (before sowing) and in 2017 (after sowing). On all variants, abundance of butterflies and wild bees are monitored regularly during the season.
In 2017, plant species number on the whole trial vineyard increased by more than 130 % compared to 2016. Although, total vegetation cover of wild plant and commercial variants is quite similar, cover of non-legume forbs is eight times higher on wild plant variants. In the first year, wild bees showed no preferences but butterflies are more abundant on wild plant variants.
Local ecotypes are not only well adapted to their respective edaphic and climatic conditions, they also provide habitats as well as food sources for many animal species. Sowing of wild plants is most effective to enhance biodiversity in vineyards.

**P-72**

**The role of microtopographical surface soil variation in boreal forest reclamation**
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In natural forests, microtopography helps drive forest development and diversity by providing conditions that vary in

soil temperature, moisture, and nutrient regimes. Current reclamation practices often heavily contour areas during reconstruction, forming relatively homogeneous surface soil conditions. Providing greater microtopographic variation on surface soils could therefore benefit forest recovery, potentially increasing diversity of forest species, and improved establishment and early growth of planted trees.
An operational scale field experiment was established to investigate growth responses of planted tree seedlings and the early natural colonization of trees and other vegetation in response to increased microtopographical variation. Surface soil microtopographic characteristics were manipulated on two slope aspects of a large overburden landform. Three microtopographic treatments were created: (i) the current operational practice of contouring surface soils leaving little microtopographic variation (control), (ii) creating parallel ridges perpendicular to the hill slope (60 cm tall, 1.5 m spacing), and (iii) large hills of loose surface material (1.5 tall, 3 m × 5 m, at 6 m spacing), from salvaged lowland and upland forest material.
Increasing microsite heterogeneity by loosely pilling surface materials forming hills provided more favourable conditions than the other two treatments. Particularly on the south-facing slope, planted seedlings grew significantly taller on the hilled treatments over control treatments. However, on the east-facing slope, these differences were not as pronounced. Hilled treatments significantly increased natural regeneration of tree and shrub species, with significantly more seedlings found on the east facing slope. Additionally, species richness and plant abundance of the colonizing vegetation community was significantly greater on the hilled treatment.
Increasing microtopographic surface soil variability creates favourable conditions for forest recovery on reclamation sites, particularly for areas with greater exposure (i.e. south facing slopes) likely providing shelter and greater access to resources.

**P-73**

**Effet of cryoprotectants and vitrificant solutions on germination of five high mountain plant species**
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High mountain ecosystems are subjected to human explotation through out door recreational activities and ski resorts is one of the major economic activities in these areas. Ski slope construction cause severe disturbances especially in the graded ski slopes. This disturbance removes the upper soil layers and the vegetation. All this disruption makes the slopes more prone to the loss of soil, seeds, nutrients and organic matter when intense rainfall occurs. In order to avoid soil erosion, ski slopes are revegetated but this process is, sometimes, very difficult and slow due to the low ability of germination of many high mountain plant species. On the other hand, the growth and development suffer very low temperatures because the activity of skiing requires compact snow and under these conditions the snow loses its thermoinsulating capacity. Our principal aim is to evaluate the effect of cryprotectants and vitrificant solutions applied to seeds of five plant species used in restoration procedures of the ski resort of Sierra Nevada (S. Spain): *Arenaria tetraquetra*, *Thymus serpylloides*, *Acinos alpinus* subsp. *meridionalis*, *Genista versicolor* and *Reseda complicata* previously treated with different phytoregulators. These seeds were conserved for three months at -15ºC and later were sown in a soil taken fron the ski slopes of Sierra Nevada. The experiments were carried out in a germination chamber Results provides evidence that these treatments can improve the seed germination and, therefore, this could contribute to restore plant cover in ski slopes with native species.

**P-74**

**Restoring Populations of the Endangered Orchid Dactylorhiza Majalis - Role of Sod Cutting on Germination**
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The wet grassland orchid species *Dactylorhiza majalis* has its main distribution area in Europe with a high share of its population occurring in Germany. This formerly common orchid is continually declining; many populations have shrunk or disappeared completely in the last 20 years. The main reason for the current decline is the abandonment of the meadows, in combination with an increasing litter layer. Especially in vegetation stands with a high coverage of tall-growing *Carex spec.* or *Scirpus sylvaticus* bare soil sites for its germination and establishment are missing.
We conducted two field experiments in the South Harz at an altitude of 370 and 420 m, in which sod cutting was tested as a suitable method for the reintroduction of *Dactylorhiza majalis* or the strengthening of individual-poor populations.
To check if sown orchid seeds actually germinate, we examined 1 x 1 m sized cut plots and uncut control plots to assess the establishment of protocorms.
In September 2017 we planted 10 seed packets per plot, consisting of a plastic slide and a nylon net with 700 enclosed seeds. On five dates we pulled out two of the seed packets per plot and counted the protocorms.
Both the cut and the uncut plots showed a development of protocorms, but only low rates, with a maximum of 7.7% on the uncut plots and 5.0% on the cut plots. Due to the disturbance by cutting the average proportion of protocorms was three to seven times lower on site 1 and 34 to 92 times on site 2.
Our results revealed that the creation of patches with low competition by other plants through sod cutting had a negative impact on protocorm development. However, the establishment of protocorms is not completely prevented and so the primary requirement for the growth of seedlings is still fulfilled.

**P-75**

**The International Network for Seed-based Restoration (INSR): An SER Thematic Section**

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The International Network for Seed-based Restoration (INSR, ser-insr.org), a thematic Section of the Society for Ecological Restoration, seeks to raise the profile of seed-based needs for ecosystem restoration. Ecological restoration is a growing sector with annual global costs exceeding a trillion dollars and seed collection and cultivation industries as important components. Thus the need to develop standards for native plant seed collection, production, testing, regulation and use is critical. INSR members and partners include professioinals, scientists, students, and representatives of industry, government and non-governmental organizations. Current participation includes more than 400 members in 43 countries and 37 partner organizations. Major goals are to: 1) advance public education, policy and awareness of the global need for native plant seed research, conservation and use; 2) sponsor a forum to promote mutual learning between stakeholders and the interchange of new iedeas, approaches, data developed and lessons learned relevant to planning, policy and science regarding native seed ecology, technology and restoration; 3) foster collaboration to develop standards for native plant seed testing and regulation; 4) serve as an emergency expert panel to address germplasm, biodiversity, conservation, seed farming and restoration issues; and 5) provide examples of best practices in seed-based restoration. To accomplish these goals, INSR sponsors conferences, worksops, field trips, webinars and forum discussions. In time we hope to provide funds to improve seed science and use in emerging economies by providing student scholarships and international grants.

**P-76**

**Ecological restoration and plant succession of dry grasslands in the Haute-Durance valley following soil disturbance**

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Large-scale ecological disturbance in grassland is increasing worldwide mainly due to land use changes and habitats destruction. The construction of high-voltage transmission lines in our study area, the Haute-Durance valley in the Southern French Alps, involves a degradation of soil and plant communities along transitory access tracks and construction platforms. In such disturbed ecosystems, restoration is limited by a lack of available propagules and low seedling recruitment due to soil degradation and/or strong summer drought. We focus on the restoration of species-rich dry to mesophilic grasslands covering a large part of the construction zone at an altitude of 1000 to 1400 m. Most of these grasslands are Natura 2000 priority habitats such as N6210 “Semi-natural dry grasslands of *Festuco-Brometalia* and scrubland facies on calcareous substrates” (EU directive habitat 92/43/EEC).

We will present the first results of a study analyzing (1) the appropriate reference community for ecological restoration, (2) hay transfer techniques to overcome dispersal limitation (3) soil preparation to facilitate establishment, (4) the required grazing intensity to favour grassland target species and to avoid the spread of ruderals and shrubs. In a second experiment, we test priority effects on plant succession and restoration by manipulating the arrival order of dominant and subordinate plant species.
Due to differences in microclimate and soil conditions depending on slope, orientation of slope and bedrock, plant communities may change at relatively small scales. Additionally, management intensity affects species assemblages. The identification of the appropriate reference community is therefore the first crucial step for successful restoration using hay transfer but also to evaluate the success of restoration efforts. We will present results on environmental drivers of plant species composition. Based on these results we will discuss the required match of source and recipient site conditions in order to restore dry grassland communities in Southern French Alps.

**P-77**

**Restoration methods, age and proximity to seed sources affect convergence of restored to old-growth forests**

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Restoration holds great promise for counteracting impacts of deforestation on biodiversity and people's livelihoods. The similarity of species composition between restored and reference forests is a measure of restoration success. Few studies have examined determinants of compositional similarity among afrotropical moist forests. We evaluated the effect of restoration methods (active vs passive), restoration age, distance from seed sources and size of restoration areas on compositional similarity between restored forests and old-growth forests in Kibale National Park, western Uganda. Trees were measured in 71 clusters of 284 permanent sample plots (2,000 $m^2$ each) in 6—19-year old actively restored forests and 21 clusters of 63 plots in 19-year old passively restored forests. Trees were also measured in 3 clusters of 5 plots in nearby old-growth forests. We determined compositional similarity per cluster using the abundance-based overlap measure. We used local area maps to estimate distance from old-growth forests, i.e. seed sources, to restored forests. We found significantly higher similarity to old-growth forests for 19-year old passively restored forests than actively restored forests of the same age since restoration started. Compositional similarity of actively restored forests increased significantly with restoration age, but decreased significantly with increase in distance from old-growth forests. The size of restoration areas did not affect compositional similarity between restored and old-growth forests. Our results show that both active and passive methods facilitate forest recovery but restoration success is higher for passive restoration where conditions are favorable for natural regeneration. Site characteristics such as proximity to seed sources and landuse history should be evaluated when choosing active or passive restoration. Tropical forest managers can identify barriers to restoration by examining compositional similarity between restored and old-growth forests along restoration age gradients to avoid waste of resources due to failure of restoration projects.

**P-78**

**Restoring rangelands in the Icelandic Highlands with the use of fertilizers**

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Patches of bare-ground are a common feature of rangelands in the Icelandic Highlands, and are exposed to accelerated erosion by wind, water and cryogenic processes. Soil erosion is a national environmental concern, especially within the volcanically active zone which has younger, less developed soils. Fertilizers are commonly used to stimulate the development of plant cover to protect soils and reduce erosion. However, the addition of fertilizers can have large impacts on nutrient-limited tundra rangelands. Further, because fertilizers are applied to areas that are used for extensive grazing during the summer, the effectiveness of these practices might be countered by increased plant consumption by sheep and other herbivores, such as geese, that could be attracted to fertilized plots.
To assess the combined effect of fertilization and grazing on rangeland restoration we established a field experiment at two locations in the Highlands of Iceland, both within and outside the volcanically active zone. At each location we focused on two habitats; a well-vegetated heath and an exposed barren area. In each habitat we established six pairs of plots; one plot in each pair was fenced to prevent access by sheep and geese. Fertilizers were applied to half of the pairs in 2016-2017. Over two growing seasons we measured aboveground net primary productivity, and the amount of bare ground in the protected, open, fertilized and non-fertilized plots.
Our results indicate that grazing can impact the short-term effectiveness of fertilizers to increase plant biomass production, but only in barren areas outside the volcanically active zone. The fertilized plots, especially in barren areas, attracted goose grazing early in the season, possibly confounding the effect of sheep grazing. Overall, responses to grazing and fertilization depended on the location and habitat investigated. Our results suggest that restoration practices need to be locally adapted to site-specific conditions.

**P-79**

**Recovery of earthworm activities in forest soil following high density of ungulates**

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In many European forests, populations of wild ungulates have reached important densities, altering both vegetation and soil structure and functioning. High densities of wild boars particularly disturb the soil fauna. Earthworms are crucial to many soil processes such as burrowing with consequences on water and air circulation, litter incorporation, boosting of microbial communities. As one of the main soil engineers, they contribute to the restoration of soil functioning in many degraded ecosystems. In restoration and management projects, it is important to better understand how earthworm populations recover and to assess their impact on soil structure and functioning. We

studied the changes in soil fauna and soil porosity (localisation, shape, number of pores) after excluding ungulates, using X-ray computed tomography, as a non-destructive technique of visualization. The study site was located in the Domain National of Chambord (DNC) in France. We tested the effect of forest cover (pine and oak), litter and presence of earthworms on soil structures and water infiltration.
We prepared 50 PVC tubes (15 cm high x 15 cm diameter) regularly drilled on the side and filed with reconstituted soil from the DNC, sealed with fabric (150µm) on the top and bottom, preventing non-soil engineers and roots to colonize them. We incubated the tubes for 3 months under various treatments (pines/oak, litter/no litter, earthworms/no earthworm). After X-ray scanning and analysis with the software ImageJ, as well as soil physico-chemical analyses, we expect to find a significant generation of porosity in the tubes with soil engineers, with enhancement of water transfer dynamics, soil aggregation and root colonization. Pine and oak cover may show different processes of water infiltration due to different earthworm density, soil structure and different litter and understory vegetation.

**P-80**

**Distribution of cow parsley in Reykjavik**
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Purpose of the research is to map the distribution of cow parsley (Anthriscus sylvestris), an invasive alien plant, within open areas of the City of Reykjavik. In addition, the distribution of sweet cicely is assessed and mapped to see if there are any synergies in distribution with cow parsley. The main aim is to identify hot spot areas with a high abundance of cow parsley. These areas have a high risk of losing native plant species due to the spread of cow parsley. Cow parsley is widely spread throughout Iceland, often creating monocultures that supplant other flora and can enhance soil erosion. It also changes landscape aesthetics. During the summer of 2017, areas with cow parsley were categorized in terms of the plant communities present, type of land, and other plant species that are found growing in the vicinity of cow parsley. The distribution and abundance of cow parsley was assessed in four plot areas; Laugarnes, Vatnsmýri, Elliðaárdalur, and Ægisíða. Preliminary results suggest that cow parsley is most abundant near riversides, streams, and pathways in Elliðaárdalur and Vatnsmýri. Lack of control measures enables further spreading of the plant species, and affects plant diversity. This research generates much needed information on the distribution and impact of cow parsley in the City of Reykjavík. Additionally, it provides baseline data to monitor future changes in distribution and species composition. Furthermore, this is the first time that cow parsley is mapped in the City of Reykjavik, which is essential for developing management and planning actions.

**P-81**

**Invasion of Senecio inaequidens and risks for honey and bee pollen in Aosta Valley (I)**
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South African ragwort (*Senecio inaequidens*) was first reported in Aosta Valley in 1990 and since then it spread widely in the region. Its leaves, stems and inflorescences contain high concentrations of pyrrolizidine alkaloids (PAs), natural toxins that can cause fatal intoxications. Humans are exposed to PAs by consumption of foods, including honey and pollen loads collected by bees.
Considering the risks to human health and the increasing diffusion of *S. inaequidens* in Aosta Valley, we aimed at: i) determine the content of PAs in honey and bee pollen; ii) investigate the role of *S. inaequidens* in contamination; iii) compare PAs content to the limits recommended by food safety authorities.
To address these challenges, we mapped the distribution of *S. inaequidens* in the middle part of Aosta Valley and collected 40 honey samples (30 from beehives in areas highly invaded by *S. inaequidens*, 10 from beehives in free or poorly colonized areas) and 9 bee pollen samples (coming from beehives in strongly invaded areas). All samples were analysed to determine the PAs content.
PAs were detected in 39 honey samples out of 40, their content ranging from 0.8 to 22.2 µg $kg^{-1}$ (mean=6.2±5.4 µg $kg^{-1}$). PAs associated to *Senecio* genus (retrorsine, senecionine and seneciphylline) were identified in most of the samples (34 out of 40), representing 40% of total PAs; their content was higher in honeys from invaded areas than in those from free areas (3.2±4.4 *vs* 0.4±0.4 µg $kg^{-1}$; $p$=0.05).
In pollen samples - all collected in invaded areas - PAs were always present, with high but very variable contents (from 60 to more than 40,000 µg $kg^{-1}$).
According to EFSA recommendations, PAs levels in these honeys do not pose a risk to human health, unlike those in pollens.

**P-82**

**Community assemblage and resistance to invasion: priority effect and seeding composition in restoration processes**
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Invasive alien species are one of the most important threats on biodiversity worldwide. The ability of exotic plants to colonize and dominate disturbed or post-disturbance areas gives them a crucial advantage. Once established they are hard to remove which can threaten the success of ecological restoration operations. Several mechanisms have been proposed to explain the success of exotic plants. In particular, biotic interactions are supposed to be involved in the containment of their development. Locally, competition for resources and space can limit the recruitment and the growth of invasive plants, both at the very early stage of propagule establishment through priority effects and also all over their growth through direct competition. Ecological restoration projects are implicitly based on these mechanisms as seeding and planting operations aim at better controlling restoration trajectories and final community composition. However it is hard to disentangle the two effects (priority and direct competition for resources) on community assemblage and particularly on resistance to invasion although they are crucial to better design restoration operations. We set up a field experiment aiming at studying the priority effect and the effect of the composition of seeding in a real restoration context. Experimental plots of 2*2m have been set along a deeply modified riverbank in the French Alps for hydraulic development purposes. We tested two densities and three seed mixes in order to study the effects of seeding composition and competition intensity. Ploughing was used to delay soil seed bank expression compared to seeding and as such to cancel its priority effects. We compared community composition and structure between treatments with a particular focus on invasive plants. Here we present the results after two growing seasons.

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