



# BEST PRACTICE IN RESTORATION

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ABSTRACT VOLUME

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## IMPRESSUM

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# HEIDELBERGCEMENT

NEUMARKTER LAMMSBRÄU



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# WELCOME

## WELCOME BY THE ORGANIZERS TO SER2016

Dear friends,

we are excited to welcome more than 300 delegates from over 40 countries to SER2016 in Freising. For two years, we have been planning this conference in close cooperation with the Board of the European Chapter of SER, supported by an excellent team of local colleagues and student helpers. We gratefully acknowledge the contributions of several sponsors without whom this conference would not have been possible. Finally, we thank our university for generously hosting this significant event.

The motto of SER2016 is 'Best Practice in Restoration Ecology' within the compartments of LAND, LIFE, PEOPLE and PRACTICE. These topics will be highlighted by six keynote speakers who kindly agreed to share their knowledge with the audience of the conference. Living our motto the 'Practitioners Day' on Tuesday will set a spotlight on regional expertise and case studies. To encourage participation of local experts we have decided to run a series of sessions in German with optional English translation. That day will also be used to set up a Central-European group of restoration experts to be affiliated with SER Europe. Poster sessions will be in the evening of Monday and Tuesday with votes for the most interesting posters. On Wednesday, our excursions will demonstrate a great diversity of field sites where restoration has been done in the past decades. Thursday offers again a multitude of interesting talks but also time to fill the SER Knowledge Base and to draft a conference declaration. Please, do not miss the membership meeting in the late afternoon. In the evening after closing the conference we invite you to the conference dinner where you can develop the most important aspect of best practice in restoration ecology – a vigorous and enjoyable network of friends and colleagues supporting our discipline and improving the ecological trajectory of our environment.

Johannes Kollmann & Julia-Maria Hermann, Chair of Restoration Ecology, TUM  
7 July 2016



*Johannes Kollmann*



*Julia-Maria Hermann*

# ORGANIZING COMMITTEE

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# KEYNOTES

## KEYNOTE

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### MANAGING SOIL FERTILITY FOR ECOLOGICAL RESTORATION

Rob Marrs

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Soil fertility is one of the main problems that restrict ecological restoration in northern Europe, especially where there is a wish to restore semi-natural communities of high conservation value. These semi-natural communities, for example grassland and heathlands, often require very infertile soils in order to maintain themselves. This is pretty well established and it is also well known that such elevated increase in fertility can be brought about through a range of mechanisms, successional processes, atmospheric pollution and of course added as fertilizers. Given elevated soil fertility can be an issue for ecological restoration, I will discuss what we can do about it. Some options are effective but very slow, others can be almost instant but can cause side-effects that the manager might not have thought about. I will review most of these approaches and assess their relative benefits and disbenefits.

## PASSIVE RESTORATION – ALLOW NATURE TO DO THE WORK INSTEAD OF US

Karel Prach<sup>1,2</sup>

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History and present use of passive (spontaneous) restoration will be reviewed. Various examples will be presented, illustrating success or failure of passive restoration, i.e. spontaneous succession, mostly regarding deeply degraded human-made habitats. Beside the totally passive approach, it will be mentioned that spontaneous succession can be manipulated to reach targets, arrested or even returned back from its trajectory. Limits and possibilities of passive restoration will be summarized as follows: Passive restoration should especially be preferred in smaller sites with low environmental stress and moderate productivity that are usually recovering from mild disturbances. A passive approach may also be preferred in those landscapes that are less altered by humans, where target species are common and both invasive aliens and strong competitive generalists remain uncommon. In such landscapes it may work even if initial disturbances are strong. Despite considerable knowledge of the effectiveness of passive restoration, its potential has not yet been fully utilized. Passive restoration is economically viable and can produce multiple social and ecological benefits economically.

## THE RESTORATION OF ECOLOGICAL INTERACTIONS

Jane Memmott

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A food web depicts species and the trophic interactions between them, similarly pollination networks characterise the interactions between pollinators and flowers, and seed dispersal networks quantify the interactions between seed dispersers and seeds. These interactions form the basis of many ecological functions and ecosystem services, and they can have a profound impact on a community's response to species loss, stress and ecological restoration. Using food webs and mutualistic networks as a tool to study ecological networks, allows both community architecture and community function to be characterised. In this talk, I will demonstrate the use of trophic and mutualistic networks in restoration ecology, using a mixture of field studies and modelling approaches, and looking forward, I will outline the areas where we need more data and better theory.

## ECOLOGY OF NOVEL AND NATIVE GRASSLAND ECOSYSTEMS

Brian Wilsey

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Native tallgrass prairies of North America have been largely converted to cropland or to grasslands dominated by non-native species. These non-native grasslands, which now dominate the region, contain species with no history of interacting because species are from multiple continents. These “novel ecosystems” might differ ecologically from native systems that they replaced in terms of biodiversity maintenance and C cycling, providing a challenge to restoration projects. In a series of studies, we compared how species origin (native vs. exotic), grazing mammals (*Bison*), species arrival order and timing of seeding, and seed source altered community assembly. Communities developed into a more diverse community when species were native in origin, when a short native bunchgrass was dominant, or when moderate grazing by bison was present. Few differences were observed in plantings with cultivars compared to plantings using local seed. Arrival order led to a completely different community depending on whether early arriving species were native or exotic, and monocultures dominated by exotic species formed when exotics arrived before natives. The strength of this priority effect was related to how much earlier the exotic grew than natives. Comparisons of intact native and exotic (novel) grasslands found that natives had a greater amount of temporal niche partitioning, better pollinator habitat, higher species diversity at the alpha and gamma levels, 10 days later green-up and 35 days earlier senescence than exotics. These phenology differences exceeded global warming effects in magnitude. In all of our restoration studies, biodiversity remained below the values of remnant areas, which supports the Humpty-Dumpty model of restoration.

## ECONOMIC BENEFITS AND INCENTIVES FOR HABITAT RESTORATION

Nick Hanley

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In this talk, I will cover two topics. The first is how we can produce estimates for the economic values associated with ecosystem restoration, when many of these benefits (such as enhanced biodiversity, or landscape improvement, or water quality improvement) are not priced by markets. Examples will be provided for two kinds of ecosystem restoration contexts: moorlands and salt marshes. The second topic is how we can incentivise private landowners to increase restoration efforts, given that the market does not reward them for many of these benefits. I therefore outline the main features of Payment for Ecosystem Service schemes that can enhance restoration, and discuss some of the problems in designing such schemes. The problems I focus on are spatial coordination and cost-effectiveness. Again, examples will be provided from moorlands and salt marshes. Finally, the talk will show how these two topics are linked with each other; and, in general, how economics can contribute to public policy debates over ecosystem restoration.

## NEW APPROACHES TO RECONSOLIDATE ECOLOGICAL RESTORATION WITHIN THE MULTIPLE LAND USE SCHEME

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Actions aiming to safeguard the biodiversity seem not to be sufficient in slowing down the rate of biodiversity loss. When different demands for the same area are weighed, biodiversity protection and ecological restoration often have to yield to the economically profitable use of the area. The focus needs therefore to shift to approaches where the biodiversity and the production of ecosystem services are assessed within the entire landscape of multiple land uses. Under an ideal situation, a combination of well-optimized land uses can simultaneously generate ecological, economic and social benefits and is therefore sustainable and widely accepted. How can this ideology be achieved? Or can it be achieved? New approaches and tools are being developed to answer to these questions, thanks to the increasing amount of data, interdisciplinary research and the continuously developing modelling methods. I present our research, in which we 1) estimate and predict the impact of land uses on the biodiversity and ecosystem services, 2) numerically optimize cost-efficient land uses so that the benefits from ecosystem services are safeguarded, and 3) analyse trade-offs concerning land-use decisions in order to find an accepted solution among stakeholders. Cases include peatlands, forests, and tourism and mining areas in boreal-subarctic Finland. The understanding of the trade-offs between land uses and ecosystem services enhances sustainable planning. Nevertheless, finding a solution that all interest groups would accept continues to be a challenge.

# SESSION 1 – RIVER RESTORATION FROM THEORY TO PRACTICE

**Chairs: Joachim Pander, Jürgen Geist**

Due to increasing awareness of the services provided by freshwater ecosystems, their restoration has become a core challenge for scientists, environmental policy makers and managers. In particular, riverine biodiversity is in decline and its restoration receives increasing international attention. To improve the status of riverine habitats, e.g. in the context of the European Water Framework Directive, it is essential to implement the most effective restoration measures, and to identify the most suitable indicators for restoration success. This session aims at describing both successful and unsuccessful restoration attempts in order to identify the factors that govern restoration success in freshwater ecosystems, with a focus on stream habitats. It also aims at bridging the gap between theoretical concepts of river restoration and applied examples.

## TOWARDS AN EVIDENCE-BASED AQUATIC RESTORATION APPROACH

Jürgen Geist

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Freshwater ecosystems, particularly streams and rivers, are among the most heavily degraded ecosystems worldwide. There is a pressing societal need to reverse the decline in biodiversity and replace lost ecosystem functioning and services in aquatic ecosystems by enabling natural recovery, or by active restoration. In the context of the European Water Framework Directive and the Natura2000 Directive, substantial effort is invested into improving and restoring aquatic habitat quality in Europe, including aspects of water quality, structural diversity, as well as connectivity. To date, many of the restoration actions are based on gut feeling rather than on scientific evidence, and many of the realized restoration projects have not yet resulted in the expected recovery of target species and communities. This contribution thus investigates the factors that are crucial for the success of stream restoration in Europe based on concrete examples. It also differentiates how the openness of a system affects the degree to which active restoration versus passive recovery can be most effective. As a first prerequisite, restoration schemes need clearly defined target states. They should generally take a process-oriented and step-wise management approach, judging success against reference or control sites. In addition to the ecological-biological targets and technical requirements, societal and political expectations need to be managed. Especially within urban settings, restoration schemes should not promise too much. Evidence-based adaptive management and publication of both positive and negative results are needed to make aquatic restoration more successful in the future.

## ADDITIONAL RESTORATION OF RESTORED STREAMS: DO BIOTA CARE?

Christer Nilsson<sup>1</sup>, Judith Sarneel<sup>1</sup>, Daniel Palm<sup>2</sup>, Johanna Gardeström<sup>1</sup>, Francesca Pilotto<sup>1</sup>, Lina Polvi<sup>1</sup>, Lovisa Lind<sup>1</sup>, Daniel Holmqvist<sup>3</sup>, Hans Lundqvist<sup>2</sup>

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Restoration of channelized streams by returning coarse sediment from stream edges to the wetted channel has become a common practice in Sweden. Yet, restoration activities do not always result in the return of desired biota. This study evaluated a restoration project in the Vindel River in northern Sweden in which practitioners further increased channel complexity of previously restored stream reaches by placing very large boulders (>1 m), trees (>8 m) and salmonid spawning gravel from adjacent upland areas into the channels. One reach restored with basic methods and another with enhanced methods were selected in each of ten different tributaries to the main channel. Geomorphic and hydraulic complexity was enhanced but the chemical composition of riparian soils and the communities of riparian plants and fish did not exhibit any clear responses to the enhanced restoration measures during the first 5 years compared to reaches restored with basic restoration methods. The variation in the collected data was among streams instead of between types of restored reaches. We conclude that biotic recovery processes in boreal river systems are very slow and that monitoring has to be long-term. Other important measures include that enhanced restoration needs to be conducted on a larger scale, and that availability of source populations has to be secured.

## IMPACTS OF GRAVEL JETTING ON SPAWNING SUBSTRATES OF LITHOPHILIC FISH SPECIES

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Anthropogenic inputs of fine sediments into freshwater systems can have deleterious effects on freshwater habitats and biota. With regard to lithophilic fish species, fine sediment accrual on and ingress into spawning gravels can detrimentally impact upon reproductive success by for example, abrading and reducing flow delivery to incubating eggs. To enhance habitat quality and increase hatch and emergence rates, river managers utilise a variety of restoration methods including but not limited to the replenishment of spawning substrates with appropriately-sized gravels, or the cleansing of existing sediments via gravel jetting. Despite the application of gravel cleaning methods being ubiquitous, few *quantitative* studies exist pertaining to their effectiveness. In these regards, two *in-situ* experiments have investigated how sediment composition and hyporheic and open-channel water properties vary as functions of gravel jetting within the River Great Ouse, UK. Whilst results indicate that jetting caused significant alterations in surface sediment compositions, the subsurface sediment composition and hyporheic water properties remained similar to pre-treatment conditions. The habitat and fishery management implications of these outputs are discussed, with an emphasis on the river's barbel (*Barbus barbus*) population.

## ESTIMATION OF SUSPENDED SEDIMENT TRANSPORT IN THE KEBIR DRAINAGE BASIN, ALGERIA

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Sediment load and sediment concentration are highly important variables that may play a key role in environment quality assessment and help to evaluate the extent of potential adverse impacts. This study introduces a methodology to predict sediment loads in the Kebir drainage basin (681 km<sup>2</sup>). The methodology is developed by a conventional sediment rating curve and a multiple regression model. The former method is investigated with the mean discharge classes derived from the recorded instantaneous suspended sediment concentrations and water discharges for the Kebir basin, prior to the Mexa reservoirs construction. After 1999, the prediction of sediment yield is based on rock type erodibility, mean annual runoff and basin area variables, and is applied for the ungauged reservoir basins. The mean annual suspended sediment yield of both Kebir drainage basin and Mexa reservoir basin conducted during the 24 years (1975/1976–1998/1999) and the 9 years (1999/2000–2007/2008) are respectively 895 T km<sup>2</sup> year<sup>-1</sup> and 572 T km<sup>2</sup> year<sup>-1</sup>. Despite the decline in sediment load during the reservoir period, due mainly to disturbance in climatic regime, the basin is suffering severe soil loss, and currently 0.42% year<sup>-1</sup> in loss of storage in the reservoir due to sedimentation has been evaluated. The high amount of sediment produced from the study drainage basin is a function of climatic and several physical factors, including the high proportion of argillaceous materials and the amount of bare soil exposed.

## THE IMPORTANCE OF LEITBILD-SPECIFIC MEASURES FOR THE SUCCESS OF RIVER RESTORATION PROJECTS USING THE EXAMPLES OF THREE UPPER AUSTRIAN WATERCOURSES

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The Upper Austrian River Aschach and its tributaries Sandbach and Leitenbach were heavily degraded by river engineering decades ago. Nevertheless, a large number of threatened species like bullhead (*Cottus gobio*), bitterling (*Rhodeus amarus*), Ukrainian brook lamprey (*Eudontomyzon mariae*) or thick-shelled river mussel (*Unio crassus*) still have remnant populations there. Hence, several restoration projects have been performed since 2005, including both the restoration of the connectivity and extensive hydromorphological measures. In the main river Aschach and its smaller tributary Sandbach, no constraints restricted the restoration measures, so these two watercourses could be reconstructed according to their respective leitbild. In the Leitenbach brook, however, the leitbild could not be complied with due to a bridge scour protection that enforced a slope far too low for the biocoenotic region. Throughout the restoration measures, comprehensive biological studies were carried out in order to monitor the development of the coenoses and of the ecological integrity. Benthic invertebrates, fish communities, najads and decapods were studied before and after several stages of the restoration works. It was shown that a leitbild-specific slope was crucial for the success of restoration projects. While in the River Aschach and the Sandbach brook the measures helped to fulfil the objectives of the water framework directive, they aggravated the situation in the Leitenbach brook.

## THEORETICAL AND MEASURED EFFECTS OF HYDROLOGICAL RESTORATION ON RIVER BIOTA IN RELATION TO HYDROPOWER PRODUCTION

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Hydropower accounts for about 43% (64 TWh) of the total Swedish electricity production of 150 TWh in a normal year. At the same time, the hydropower development has resulted in impoverishment of riverine biodiversity and biotopes both locally and regionally. Flow regulation causes fast changes in the amount of water in rivers and streams which in turn affects both animals and plants in and near the watercourses, as well as changes substratum composition (erosion and deposition). Hydropower thus affects ecosystem function and services related to tourism, fisheries, water purification etc. In this study we have identified some 200 hydropower stations in Sweden where we also have biological sampling data (fish, benthic macroinvertebrates, macrophytes, diatoms, large mussels) and information on gradients in hydrological stress levels. Thus, we assess how hydrological restoration of water courses can be performed and verify the importance of minimum and seasonal differences in flow. We will discuss the theoretical and practical implications of hydrological stress and restoration for different riverine biota.

## RESTORATION OF FISH HABITAT ADAPTED TO LOCAL OPPORTUNITIES – EXAMPLES FROM TWO CASE STUDIES

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Restoration of antropogenically impaired rivers is challenged by political, conservational and financial aspects. We here present two successful approaches that meet specific demands on and possibilities of these waters: one at the creek Mitternacher Ohe, which was compromised by migration barriers, the second at the river Lech, which is influenced by large power plants, a highly mobile bed and loss of spawning grounds. Based on deficit analyses of aquatic biocoenoses and on legal options, the Bavarian Fishing Association (LFV Bayern) identified suitable measures and conducted representative pilot studies on these rivers. At the Mitternacher Ohe, the LFV Bayern bought up water rights from three small powerplants, deleted weirs and reguiled full flow over natural riverbed to its former bed. This enabled remigration of autochthonous species like *Hucho hucho* and *Lamprreta fluviatilis* and cessation of turbine-caused fish casualties. Also, conditions for the pearl mussle *Margaritifera margaritifera* improved. At the Lech, introduction of gravel effectively supported spawning of *Hucho* and other fish that are key species to this river, but, as impact by powerplants remains, measures will need to be repeated. In addition, we demonstrate for the upper Isar, a reference river due to its near-natural, dynamic structure, how important driftwood deposits are for fish in various life stages, particularly as winter habitats for the 0+/1+ generations of *Hucho*.



## RESPONSES OF BENTHIC MACROINVERTEBRATES TO STREAM RESTORATION AFTER TIMBER FLOATING

Francesca Pilotto, Lina E. Polvi, Christer Nilsson

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The use of streams as waterways to transport timber, a practice known as timber floating, has been common in northern Sweden from the mid-1800s to the 1970s. To facilitate timber floating and reduce the risk of log jams, streams were heavily modified, by e.g. removing large boulders, building splash dams and closing side channels. These morphological alterations caused a decrease in physical heterogeneity and in longitudinal and lateral connectivity, which has affected biodiversity and ecosystem functions. Our study was conducted at 20 stream reaches along tributaries to the Vindel River where, starting in the 1970s, a series of restoration measures has been undertaken to enhance physical and biotic diversity after timber floating. The aims of this study were to evaluate biotic recovery in response to stream restoration and to identify its driving factors. Therefore, we quantified the relative importance of (1) physical complexity, as created by the channelization and restoration measures, (2) quality of the surrounding potential aquatic and terrestrial re-colonization routes, and (3) the time since restoration, in shaping the taxonomic and functional structure of benthic macroinvertebrate assemblages. The results of this study allow for a better understanding of the factors driving biotic recovery after stream restoration, which is crucial for successful planning of future restoration projects.

## REQUIREMENTS FOR RESTORATION MEASURES IN LARGE RIVERS TO PROMOTE AQUATIC ORGANISMS SUCCESSFULLY

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Large navigable rivers are used by humans in many ways. For this purpose, they have been optimized in the past by maintenance for water management and hydraulic engineering measures. In particular, the stability of the banks was protected by technical, engineering measures. Faunistic sampling in the river flow cross section shows that just in these shore and bank areas, most of the settlement by benthic aquatic organisms (benthic invertebrates and fishes) can be found. Therefore, to increase biodiversity in large rivers, restoration measures of the riverbanks and the choice of materials and techniques used for bank protection are promising. In this sense, first, the faunistic colonization situation and the long-lasting faunistic development in large navigable German rivers are characterized. Special focus is on the reshaping of settlement structures by invasive non-indigenous species. Results about interactions of fauna with bank structures and the materials and techniques used for bank protection will be presented. Based on these results, characteristics are derived that are expected to provide successful promotion of settlement structures and biodiversity of aquatic organisms in the context of restoration measures.

## RIVER RESTORATION: FROM “JUST DO IT” TO STATEWIDE CONCEPTS AND PRACTICAL IMPLEMENTATION IN BAVARIA

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Since the beginning of ecology-based river restoration in Bavaria 30 years ago, four phases can be detected. Phase I was marked by a “Just do it” approach in rivers that offered favourable conditions. With the beginning of phase II, based on a statewide code, river restoration concepts were developed and implemented. The resulting basic documents were established for about 80% of the larger rivers. At the smaller, municipal scale, river restoration concepts, co-financed by the free state of Bavaria, were implemented for ca. half of the municipalities. In phase III, ca. 5 years ago, under the Water Framework Directive (WFD), programmes of restoration measures were elaborated in further detail. For more than half of the surface water bodies, supplementary measures for hydromorphological amelioration proved necessary to achieve a good ecological status. Important tools are restoration concepts that function for entire WFD water bodies. Phase IV is characterized by the necessity to prioritize and achieve synergies with other requirements such as flood risk management, Bavaria’s Flood Action Programme, and Natura2000. An operative instrument for the achievement of synergies is “ecological development planning”. More than 5.000 river restorations implemented by the Bavarian State Water Management over a span of the last 15 years are a success. But efforts have to be continued. To assure continued success, 40 million Euros per annum have been allocated to this task in the 2<sup>nd</sup> management period.

## APPLYING THE WATER FRAMEWORK DIRECTIVE LENS TO ENHANCEMENT STRATEGIES IN IRISH RIVER FISHERIES

Brian Coghlan<sup>1,2</sup>, Nathy Gilligan<sup>3</sup>, Karen Delanty<sup>1</sup>, Rossa Ó Briain<sup>1</sup>, James King<sup>1</sup>

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Arterial drainage, undertaken on circa 11,000 km of channels in Ireland since 1950, has substantially altered the hydromorphology and ecology of impacted channels. In response, fisheries agencies developed instream works techniques to offset the impacts of drainage on salmonid populations. Since the 1990’s, these “Capital Works” programmes have constructed instream structures, augmented gravels and protected the immediate riparian zone, all aimed at improving ecology and hydromorphology. Thirty-two Capital Works locations were analysed utilising the Irish Water Framework Directive (WFD) Fish Ecological Quality Ratio (EQR) tool. The fish data consisted of one-year pre works and up to 5 years post works. The capital works locations represented both varying levels of water quality and a broad spread of locations around Ireland. Initial analysis showed a non-significant increase in EQR’s post capital Works ( $P = 0.79$ ). Removing poor water quality sites from the analysis resulted in a significant ( $P = 0.003$ ) increase in EQR ratios that were sustained post works, underlining the importance of water quality screening at proposed works locations. The EQR also indicated that rivers classified as Good or High were subject to works. This may not reflect cost-effective expenditure in terms of the WFD. Analysis suggests focusing on “Moderate” fish EQR status sites will generate the most cost effective returns in capital investment, having the greatest potential to achieve WFD goals.

## LARGE-SCALE HABITAT RESTORATION: APPROACH, IMPLEMENTATION AND INTENTIONS AT RIVER INN, GERMANY

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In southern Germany, most rivers are regulated resulting in reduced biodiversity and degraded ecosystem functions. Therefore, the hydropower company VERBUND Innkraftwerke GmbH has implemented several revitalisation measures along a 40-km section of River Inn since 2011. The main aim is to improve both aquatic and terrestrial biodiversity according to the German Water Law and the EU Water Framework Directive. Since for large power plants technical solutions for fish protection at the plant itself are questionable, a different approach had to be developed. A multidisciplinary planning team, the relevant authorities and NGOs including local fisheries prepared an innovative restoration concept. An evaluation of existing structures was done and a concept for new measures for a “fish-habitat model” developed, starting with a general orientation of the heavily modified river and its fish populations. The main aim was to rehabilitate essential habitats for the entire life cycle of current and future fish populations. This includes habitats for spawning, larval, juvenile and adult stages of the rheophilic sneep (*Chondrostoma nasus*), barb (*Barbus barbus*), greyling (*Thymallus thymallus*) and Danube salmon (*Hucho hucho*), but also the common and mainly limnophilic species chub (*Leuciscus cephalus*), bream (*Abramis brama*) or roach (*Rutilus rutilus*), that are prey for predators like cormorant (*Phalacrocorax carbo*) and goosander (*Mergus merganser*). To follow up on the efficiency and sustainability of the revitalisation measures, a scientific monitoring is done for 10 years. First results will be reported. The main aim is to find a systematic and successful approach that can be applied to other sections of River Inn and other prealpine rivers.

## ESTABLISHING A “GOOD ECOLOGICAL POTENTIAL” OF THE MÜNSTER AA, A HARD-SEALED URBAN CHANNEL – A TECHNICAL DESIGN OF HYDRAULIC AND ECOLOGICAL NICHES

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The “Münster City Aa” (West Germany), a third order lowland stream, is a hard-sealed urban channel stretch with high runoff variability. The city of Münster is encouraged to establish “good ecological potential” for the channel. With a eutrophic man-made lake upstream, it corresponds to the synthetic water type “lake-outlets of German lowlands”. The challenge is to meet the requirements of the WFD considering high seston transport and effective flood protection. In 2012, a pilot reach was installed in the urban Aa for testing technical solutions of ecological enhancement. The concrete bed was replaced by sediment mixtures and morphological structures. Additionally, various technical choriotores were installed according to ethohydraulic demands of water type-specific benthos. Morphodynamic simulations and measurements confirmed complex shear stress processes causing sediment instabilities near structural elements. Nevertheless, macroinvertebrate diversity increased significantly in the pilot reach compared to the previous situation and more parsimonious solutions. Long-term stability and flow balance were studied on technical choriotores for a stocking with water type-specific faunal elements. Hydraulic and morphological variability are discussed as promoters of biodiversity but also as a principal limitation of ethohydraulic solutions.

## LIFE+ PROJECT “LIVING SPACE IN THE ESTUARY STRETCH OF RIVER TRAISEN”

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The river Traisen is one of the biggest tributaries of the river Danube in Lower Austria. During the construction of the Danube hydropower plant of Altenwörth, the mouth of the river Traisen was relocated about 7.5 km downstream. This monotonous, heavily regulated river stretch runs through the Natura2000 site “Tullnerfelder Donauauen”, Austria’s largest enclosed wetlands. During the LIFE+ project an ca. 10 km long, meandering river segment is built and allowed to develop dynamically during floodwater situations. Ca. 30 ha of typical river habitats are created that help to achieve “good ecological potential” of the adjacent water body of river Danube (the water reservoir of the Danube hydropower plant Greifenstein). Another priority of the project is to re-connect the river Traisen to the river Danube and its fish population. The adjacent area is lowered to create about 60 ha of floodplain habitats, especially silver willow riparian forest, typical for the Natura2000 site. The large-scale material removal during the establishment of the riverbed and its adjacent floodplain results in a material surplus of ca. 1.9 million m<sup>3</sup>. Part of the gravel is used for sediment management downstream the Danube hydropower plant “Wien-Freudenau”, another part is supplied for construction purposes. Most of the gravel is transported on the Danube inland waterway. Ca. 800,000 m<sup>3</sup> of fine-grained sediment (clay and sand) are backfilled within the project area after gravel extraction. The project is the largest LIFE+ nature project in Austria, regarding both planning area and construction volume. It is also one of the largest revitalization projects in Central Europe. The project started in 2013 and is expected to end in 2017. First monitoring results from the sections already built and flooded show significant improvements of ecological conditions.

## WHAT DO WE KNOW ABOUT RIVER RESTORATION EFFECTS? PLACING THE RESULTS OF THE EU-FP7 REFORM PROJECT IN THE BROADER CONTEXT OF RESTORATION LITERATURE

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Although there are still major knowledge gaps regarding the effects of river restoration, considerable progress has been made in recent years. An increasing number of primary research studies reported monitoring results, which already have been summarized in several narrative reviews and quantitative meta-analyses. Moreover, there is a growing number of studies on multiple restoration projects and multiple organism groups. Recently, several publications on two tasks of the REFORM project (www.reformrivers.eu/) were added to this growing body of literature. In a top-down approach, information from literature and unpublished databases were compiled in a meta-analysis on fish, macroinvertebrates and macrophytes, and factors influencing restoration outcomes were identified. In a bottom-up approach, a harmonized dataset on 20 restored river segments was compiled and a broad range of response variables was investigated, including aquatic and terrestrial habitats, three aquatic and two floodplain-inhabiting organism groups, as well as aquatic land interactions as reflected by stable isotopes. In this presentation, these recent studies will be placed in the broader context of restoration literature: The present knowledge on the overall effect, as well as the effect of different restoration measures on different organism groups and traits will be summarized, prior to discussing possible reasons for low or negative effects and drawing more general conclusions for river management.

## USING BIOTOPES AS UNITS FOR MONITORING SUCCESS OF STREAM RESTORATION: EFFECTS OF WOODY DEBRIS DAMS IN A SMALL RURAL STREAM ON MACROINVERTEBRATE COMMUNITY

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The construction of woody debris dams in small streams leads to high rates of organic matter retention, an increase of riffle-pool sequences, and physical habitat enhancement. The biotic responses to such hydromorphologic enhancements, however, especially changes in macroinvertebrate diversity and richness – which are commonly used as biodiversity tools in monitoring studies – are still not clear. An appropriate standardised method for monitoring the success of streambed modifications is lacking. In this case-study, we quantified the effects and outcomes of using woody debris for restoring a previously straightened headwater stream of River Welland (England). We mapped the stream biotopes and then measured leaf retention capacity and macroinvertebrate species composition in three replicates of each biotope at the finest scale in a BACI sample design. Samples were taken once before the restoration process and after over two years from all biotopes that comprised more than 1% of the total study reach area. The physical and biological changes following stream restoration were evaluated, and are discussed here in an attempt to assess the suitability of macroinvertebrate metrics at the biotope unit level as tool to quantify the outcomes of stream restoration.

## A FRAMEWORK FOR PREDICTING STREAM SITES WITH POTENTIAL RESTORATION SUCCESS - INTEGRATING ECOGEOMORPHOLOGY INTO A LANDSCAPE PERSPECTIVE

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Ecological responses to stream restoration often do not meet desired outcomes. Although targets for abiotic components are met, levels of biodiversity remain low or only slightly increase. Existing studies of restoration results are unable to fully explain this observation. The majority of these investigations have been conducted at the reach scale, at an order of up to a few hundred meters. Explanations for low biodiversity after restoration may, however, only come to light at larger spatial scales and when analysing the adjacent landscape and large-scale factors, including proximity to colonization pools, influence of land use, effects of geomorphological features and connectivity within the catchment. Another characteristic of restoration studies is the lack of combining biotic and abiotic factors. Streams in northern Sweden have undergone several phases of restoration since the 1980s, after over a century of channelization from timber floating, and studies have demonstrated a slow recovery of riparian and instream biodiversity. We present a framework for integrating eco-geomorphology, the study of interactions between ecological and geomorphic processes, with a range of spatial scales, to better understand fluvial ecosystems and benefit stream restoration design in northern Sweden. Through this framework, we provide hypotheses on how to predict potential for biotic recovery and assist in the planning and localization of restoration efforts.

## HOW TO ESTABLISH THE LINK BETWEEN HYDROMORPHOLOGICAL INDICATORS AND ECOLOGICAL INDICATORS IN A CONTEXT OF RIVER RESTORATION?

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The French national standard to describe hydromorphological measurements is called CarHyCE (Characterization of streams hydromorphology). This habitat survey method is applied on river stretches of 14 times the full bank river width. A large variety of parameters are taken into account, measured or evaluated in the field: geometry of the bed and width, depth and flow, slope of the water line, description of channel geomorphic units, granulometry, organic substrates, type and thickness of river bank vegetation, longitudinal and lateral continuities. In the framework of restoration programs, we explore the relationships between hydromorphological features and bio/ecological traits of macroinvertebrates within the four dimensions of the river ecosystems. For example, considering the lateral distribution, the CarHyCE protocol provides the full bank height and width, which could potentially be used as a ratio correlated with several traits such as the transversal distribution describing the use by species of hydraulic annexes. We explore these potential relationships within the framework of a project devoted to the research of biological indicators of river restoration programs (mainly over at least 5 years in ranks 2 to 6 according to the Strahler classification). The test of several hypotheses could help to integrate species traits in the evaluation methods of river restoration to transform descriptive community ecology into a predictive science.

## EXPLORING RIVERINE LANDSCAPE PATTERNS AND THE DRIVING FORCES

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Rivers provide critically important ecosystem services to society, and play an essential role in maintaining the structure, function, and integrity of landscapes in which the rivers reside. The restoration and management of river systems have long suffered from narrow scopes, and inconsistent perspectives. Better understanding of the patterns and processes in river systems requires a broader landscape view that goes beyond the traditional linear and longitudinal focus. We deployed a riverscape transect approach to explore four riverscape patterns (Dongjiang River and Beijiang River in southern China, Severn River in UK and Chippewa River in USA), as well as their associations with natural and social-economical driving forces. We generated a buffers ranging 5 km in width, and constructed a range of overlapping neighbourhood landscapes for each buffer. Following that, we computed a selected set of landscape metrics, and finally depicted the continuous longitudinal profile of those rivers. To acquire geological traits, we used focal analysis in ArcGIS, constructing analysing circle windows whose radius varies in accordance with the landscape analysis windows. Social-economic factors were acquired from local statistical data. All the riverscape displayed similar patterns at class and landscape level. Specifically, at landscape level, patch density - which reflects shape complexity - decreases while the landscape diversity (represented by SHDI) increases from headwater to mouth. Analysis of correlations showed that patch density and SHDI was more related to geological factors (average altitude, average slope and the relief degree of land surface) than to social-economic factors (population density and per capita GDP). There is a predictable riverscape pattern change in which landscape diversity increases while complexity decreases from headwater to mouth. Our research proposed this land-use model which can be used for better understanding the longitudinal and horizontal dynamics of river landscapes, as well as for effectively planning and monitoring river restoration and management efforts.

# SESSION 2 – FLOODPLAIN RESTORATION IN MODIFIED LANDSCAPES

**Chairs: Barbara Stammel, Kathrin Kiehl**

Floodplain restoration – the challenge to deal with river dynamics in anthropogenically transformed landscapes. Natural floodplains are multifunctional ecosystems driven by the dynamics of water and sediment. The varying mosaic of habitats ranging from aquatic to very dry conditions depends on the oscillating processes of inundation and drought, erosion and sedimentation, disturbance and resilience. Therefore, intact floodplains are hotspots of biodiversity with many specialized plant and animal species. Since the 19<sup>th</sup> century, however, European floodplains and rivers have more and more been disconnected from natural dynamics and have been degrading ever since due to flood control, hydropower generation, agricultural use and shipping. Ecological restoration of degraded more or less static floodplains has to bring back the dynamics of water and sediment by more natural or – under restricted local hydrological conditions – even by regulated flooding regimes. The aim is to restore suitable habitat conditions in order to foster species typical for floodplains which might re-establish either from the seed-bank or by natural dispersal from intact upstream habitats. Due to the spatial requirements, the competing human interests in river corridors and the need to divert water from the river back into the floodplain, floodplain restoration is a major challenge.

In this special session we would like to discuss the following questions: (1) To what extent is the restoration of natural river and floodplain dynamics possible, when water and sediment dynamics remain partly restricted by the ongoing land-use? (2) How can we cope with these restrictions to ensure appropriate water dynamics in floodplains? (3) Which are the limiting factors for the recolonization of different target species groups (e.g. plants, invertebrates, fish)? (4) Are typical floodplain species able to re-colonize formerly disconnected floodplains only by restoring more natural flood dynamics? (5) What is the effect of disturbance by restoration measures on the establishment of target and non-target species? – The session will present research results from different floodplains in Europe, both from different explicit restoration projects and modelling of potential scenarios for the different habitat types.

## POTENTIAL EFFECTS OF RESTORATION MEASURES ON ECOSYSTEM PROPERTIES IN AN URBAN FLOODPLAIN

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Floodplains in the vicinity of urban areas and intensely used landscapes can be areas of conflicting interests, ranging from different land use types, flood water retention, drinking water production and recreation to conservation of last remnants of a former riverine landscape, as is the case in several floodplains along the Upper Danube in Austria. The massive alteration of riverine landscapes has led to increasing efforts in water management, integrating different targets such as flood water protection and especially rehabilitation activities to improve aquatic ecosystem conditions and to compensate for the effects of river regulation in areas of high nature value. Thus, several rehabilitation approaches leading to increased surface water connectivity between the main channel and floodplain areas were analysed with regard to the effect on fundamental ecosystem properties such as nutrient and carbon dynamics and biodiversity patterns. Management approaches based on controlled and highly managed reconnection measures that improve only the floodplain water balance (a controlled water enhancement scheme) will be compared to approaches where mainly riverine dynamics are re-introduced, leading to frequent flowing conditions in former side-arms. We expect that the controlled water enhancement scheme can partially mitigate the trend of reduced water surface area in the floodplain without introducing features of the pre-regulation conditions, while the introduction of riverine dynamics will approach pre-regulations conditions. Potential long-term changes and critical thresholds in responses of fundamental ecosystem properties will be discussed, based on habitat modelling, trophic modelling and experimental work.



## DIKE RE LOCATION ALONG THE RIVER ELBE: EFFECTS ON VEGETATION, MOLLUSCS AND INVERTEBRATES

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In the last centuries, the Elbe river lost 80% of its retention areas due to dike constructions for flood prevention. This led to severe damage or destruction of many essential wetland habitats. Providing more space for the river by opening former floodplains is a chance to combine flood risk management with biodiversity functioning. Also in the Middle Elbe, stakeholders have attended to this challenge. The “Roßlauer Oberluch” was the first large dike relocation project along the river Elbe, implemented in 2006. To study exemplarily the effects of floodplain restoration on biodiversity and ecosystem status, a specific floodplain research platform was established by the UFZ as part of the TERENO observatory programme. In particular, a stratified, randomised study design with interdisciplinary study plots sets the scientific basis to all participating disciplines. It enables repeated surveys of the same plots for biotic (molluscs, insects, vegetation) and abiotic (soil, nutrients, pollutants, hydrology) factors. Until now, for all disciplines a pre-flood survey was carried out. Mollusc communities differed between the three sub-areas, being more diverse in the active floodplain, whereas ground beetles and grasshopper community composition mainly depended on small-scale morphological features. Vegetation is more diverse in the restoration and reference areas than in the active floodplain where nutrient loads from the Elbe may favour nitrophytes. First flooding of the restoration area by the Elbe occurred in spring 2009 and the field monitoring is ongoing. Results of the effects on biodiversity are visible especially for molluscs but less for plants, and will be presented.

## EFFECTS OF RIVER RESTORATION ON RIPARIAN GROUND BEETLES (COLEOPTERA: CARABIDAE) IN EUROPE

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Riparian ground beetles are well-known indicators for human-caused changes in environmental conditions. Due to their specific habitat preferences they show fast reactions to changing habitats, e.g. to hydromorphological river and floodplain restoration. However, studies addressing restoration effects on riparian communities mainly focus on single or a few river sections. Thus, knowledge about general restoration effects across Europe is missing. Moreover, it is not known if restoration effects on ground beetles differ between the type of restoration measure or depend on the size of restored sections. We investigated ground beetle assemblages in riparian areas of 20 restored and 20 degraded rivers across Europe. We analysed (1) if morphological river restoration increases richness and diversity of ground beetles, (2) if effects of restoration on ground beetles depend on restoration measure types or the extent of restored sections, and (3) which environmental parameters determine changes in ground beetle assemblages. In general, restoration increased ground beetle richness by about three species, whereas the size of restored sections has no significant effect. In restored sections where widening was applied as a restoration measure, species richness was increased by around seven species. Thereby, the creation of pioneer patches in rivers with strong hydraulic power was a key factor for the colonization by riparian specialists indicating river dynamics. Widening is an appropriate measure in high-gradient rivers as flooding maintains created habitat mosaics and characteristic dynamic riparian areas.



## RESTORING RIPARIAN VEGETATION ALONG RIVERS USED FOR HYDROPOWER PRODUCTION

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One effect of hydropower is hydropeaking, caused by sub-daily fluctuations of water-level because of variable turbine operation. We aim to investigate the effects of hydropeaking on the recruitment and performance of riparian vegetation, in order to identify (1) the stages in the plants' life-cycle critically affected by hydropeaking, (2) hydropeaking thresholds above which the impact is irreversible, and (3) plant species suitable for measuring hydropeaking impact, and for restoration and monitoring. This is necessary for designing restoration measures. We used several plant species as indicators of the effects of hydropeaking. Seedlings and seeds were transplanted to five river reaches and bank elevations along a hydropeaking gradient from none to high hydropeaking intensity in Sweden, and germination, growth, vigour and survival were studied. *Carex acuta* and *Salix myrsinifolia x phyllicifolia* showed significant increases in response to the hydropeaking gradient, whereas *Betula pubescens* was disfavoured. *Helianthus annuus* showed no significant responses to hydropeaking. Germination for all native species was significantly lower along the reaches affected by hydropeaking. These findings show that recruitment represents a bottleneck in the management of riparian communities along rivers affected by hydropeaking, and they highlight the importance of "operational" restoration actions focused on favouring the germination of riparian species by flow manipulations. In addition, results also show good seedlings performance and survival of *Carex* and *Salix* species, which encourages plantation of certain native species to restore bare and highly erodible river margins.

## COMBINING FIELD STUDIES WITH VEGETATION MODELLING TO GUIDE FUTURE FLOODPLAIN WOODS RECOVERY IN ALTERED RIVER BASINS OF SOUTHERN EUROPE

Patricia María Rodríguez-González<sup>1</sup>, Rui Rivaes<sup>1</sup>, Filipe Campelo<sup>2</sup>, Inês Marques<sup>1</sup>, António Albuquerque<sup>3</sup>, Gregory Egger<sup>4</sup>, António Pinheiro<sup>5</sup>, Maria Teresa Ferreira<sup>1</sup>

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Reciprocal interactions between stream flow and vegetation are key riparian drivers. Riparian trees are ecosystem engineers that modify topography and adjust landform evolution, maintenance and turnover depending, among other factors, on vegetation succession and growth rates. Yet, widespread anthropogenic activity modified natural disturbance regimes; thus, recovering dynamics in altered floodplains is a top-priority target in restoration ecology. We combined an intensive field survey of riparian trees (past growth trends of dominant species) with a process-based model, based in vegetation succession dynamics (CASiMiR-vegetation) to explore the potential of integrating both approaches to improve floodplain vegetation restoration. The study area was a Mediterranean hydrographic basin in Southern Portugal, where the model was applied to assess the riparian patch dynamics predicted for different hydrologic alteration scenarios (flow regime changes derived from either climate change, flow regulation of flow restoration), and where dendrochronology was used to analyse tree-ring growth across morphodynamic disturbance gradients resulting from flood events and associated river processes (i.e. sediment transport or drag forces). Both approaches reflected sensitivity of riparian vegetation to flooding regime, but at different scales. Model results revealed shifts in the patches mosaic, in response to changes in the intensity and distribution of floods, at the pioneer and young successional stages, and field data showed different radial growth rates of younger *Alnus glutinosa* trees across the morphodynamic disturbance gradient. The results raised questions and opportunities about the integration of these complementary approaches for the rehabilitation of sustainable floodplain woods, based on the survival and growth requirements of riparian species.

## RIVER AND FLOODPLAIN RESTORATION ON THE UPPER DANUBE BY RE-ESTABLISHING RIVER CONTINUUM AND ECOLOGICAL FLOODING

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The upper Danube and its floodplain lost natural dynamics and river continuum in the 19<sup>th</sup> and 20<sup>th</sup> century due to river regulations. Consequently, groundwater fluctuations and flooding events declined. Additionally, hydropower dams are preventing migration of aquatic organism and caused a loss of stream habitats. Measures have been taken to improve river continuum, flood dynamic and groundwater variation. Three major measures have been performed to enhance ecological conditions in the largest remaining alluvial forest with 2.100 ha between Neuburg and Ingolstadt on the German Danube: (1) Construction of an 8-km long river system bypassing Bergheim hydropower dam, in order to create new stream habitats and to provide length and lateral connection. (2) Frequent controlled ecological flooding of the floodplain forest. (3) Controlled changes in groundwater table to support floodplain vegetation. Total investment of the project was 15 Mio. €, including 1 Mio. € for monitoring of the aquatic system and of the floodplain forest to evaluate the efficiency of the taken measures.

## RESTORATION OF FLUCTUATING WATER ZONES IN FLOODPLAINS BY TEMPORARY GROUNDWATER DRAW DOWN: CASE STUDY OF THE DANUBE FLOODPLAIN IN BAVARIA

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The Danube floodplain is disconnected from its river, and natural water dynamics are inhibited by regulation and hydropower generation. In spite of the dam, a restoration project aims to bring back natural water dynamics to the floodplain by a floodplain stream, ecological flooding and temporary groundwater drawdown during summer months. Due to the new floodplain stream, former fluctuating water zones that were habitat for the target species *Oenanthe aquatica* changed into aquatic habitats. The measure groundwater drawdown aims now to enhance the abiotic conditions for this pioneer species of muddy streambanks. The scientific efficiency control compares the situation before restoration implementation with the effects of three different types of groundwater drawdown (GD): (1) original GD, complete water stop in a part of the new stream, (2) improved GD with an e-flow of 100 l/s, and (3) low water-situation in the stream. For these three types, occurring in three different years, the hydrological situation (stream, water bodies, groundwater) was investigated and compared. For the three time slots 'before restoration', 'without GD' and 'during GD', the effects on the potential area and on the occurrence of *O. aquatica* were mapped. The outcome is that one type can enhance germination of *O. aquatica*, but is detrimental for aquatic organisms. The other type is able to provide the same suitable conditions for *O. aquatica*, without severely harming the aquatic habitats. The third type cannot reach the needed low water levels and is therefore not a comparable option. The results show that interdisciplinary monitoring is suitable to develop a measure suitable for both competing habitat types.

## BIOLOGICAL COMMUNITY RESPONSES TO A LARGE-SCALE FLOODPLAIN RESTORATION AT THE UPPER DANUBE RIVER

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The Danube River is considered a European biodiversity hotspot, yet its serial continuity and connection with its former floodplains is severely degraded. Within the largest remaining alluvial forest in the upper Danube catchment, a large-scale floodplain restoration was carried out. We used this setting in order to test which factors drive colonization speed and colonization success in aquatic species depending on their functional traits, as well as to assess the contribution of this floodplain reconnection in a large river to aquatic biodiversity restoration. The effects were quantified considering abiotic habitat properties as well as the community structures of fishes, macroinvertebrates, macrophytes and periphyton. The newly created 8-km long floodplain channel provided important key habitats for juvenile and small rheophilic fishes as well as for a large number of macroinvertebrate taxa of high conservation value. Consequently, reconnected secondary channels can play an important role as compensatory habitats. Also, pronounced differences in habitat preference and colonization patterns between native and non-native species were found. These differences in colonization patterns suggest that the applied construction scheme with gravel dominated and fast flowing river sections is potentially useful to prevent invasions with non-desired taxa into restored systems.

## VEGETATION DEVELOPMENT IN A RE-CONNECTED OXBOW SYSTEM OF THE DANUBE IN SOUTHERN GERMANY

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Since June 2010, a new watercourse is running in oxbows and backwaters of the Danube floodplain between Neuburg and Ingolstadt (Bavaria) to re-connect the floodplain to the river and to enhance fluvial dynamics. Vegetation monitoring from 2007 to 2013 provided detailed baseline data and recorded the development of the first three years after restoration. Nineteen transects of 20 m to 110 m length were installed across the watercourse in order to analyse small-scale changes in vegetation zonation. In addition, 99 permanent plots were placed randomly in different zones along the water body. Vegetation analyses indicated different successional pathways depending on initial conditions and zones of the water body. Species richness and number of target species increased continuously in formerly dry oxbows or sections with ancient temporary water bodies, while they decreased in large ancient backwaters in the first year and got back to the starting level afterwards. Changes in vegetation composition were most pronounced in the river bed and on the river bank and less in the secondary floodplain. Areas with bare ground due to construction measures showed generally increasing vegetation cover. In parts with formerly dense reed vegetation, however, the proportion of bare soil increased. Several floodplain species, which had been found only in the soil seed bank before, could be detected in the actual vegetation after restoration. These were mainly species of the *Bidentetea tripartitae*. The results indicated an enhancement of typical floodplain habitats, but they are restricted to a small corridor. To maintain these processes for a long-term and a large-scale development the fluvial dynamics as driving factor have to be adapted.

## DOES THE RENATURATION PROCESS BENEFIT SPECIES RICHNESS?

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Along the upper Danube close to Neuburg (Bavaria, Germany), a hardwood forest was reconnected to the river via a new floodplain channel and occasional flooding events. We report here the stepwise alteration of the beetle diversity in the study area for six successive years. We recorded beetle communities in a two-year preliminary period (2007–2008), the period when technical measures were implemented (2009–2010), and during the onset of restoration (2011–2012). Each of our 20 sample plots was equipped with a pitfall trap, an emergence trap, a trap on a trunk, a flight interception trap, each at breast height and in the canopy. Within the six-year study period we trapped 62,107 individual beetles, representing 85 families, 544 genera and 1,191 species. The results show that the implementation of the restoration process decreased the species richness. This is true for the entire list of observed species, species estimator Chao 1, alpha diversity, species of selected dominant families, rare species, and for red list species. Furthermore, the same decline is found for abundances of all species and red list species. Although floodplains are known hotspots of biodiversity, the initial phase of a floodplain restoration process represents a significant disturbance of the previously existing system causing a downtrend in beetle diversity.

## RE-DYNAMISATION OF REGULATED ALPINE RIVERS? A CASE STUDY AT RIVER LECH

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River regulation has changed the hydro- and morphodynamic processes in most alpine floodplains, leading to a decline and regional extinction of specialized pioneer communities. River Lech in S Germany is highly affected by hydropower stations and flood protection, and thus re-dynamisation measures are very much wanted. This study evaluates the potential for re-dynamisation on the basis of a detailed inventory of the current vegetation in one pre-alpine section of this river. The study site is the last free-flowing part of River Lech in Germany, the "Litzauer Schleife". There, gravel bars are mostly overgrown with willow shrubs and softwood forests as a consequence of lacking gravel supply and reduced flooding. Open gravel bars without vegetation or just light plant cover still exist in about 20% of the floodplain, but they are mostly under the influence of the hydro-peaking management of the power plants and therefore unsuitable for plant colonization. As a result of this habitat alteration, no characteristic pioneer plant communities remain, while some rare alpine species still occur sporadically in open habitats. Because of the reduced diversity of characteristic species and the advanced succession in combination with a lack of gravel supply there is only limited potential for re-dynamisation of this river section. Management should concentrate on the preservation and creation of open gravel areas above the hydro-peaking zone.

## LIFE FEUCHTWÄLDER – CONSERVATION AND RESTORATION OF ALLUVIAL FORESTS AND BOG WOODLAND IN BRANDENBURG

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From the middle of 2014 to 2022, the NaturSchutzFonds Brandenburg [Nature Conservation Foundation of Brandenburg] is undertaking a *LIFE* Nature project for the conservation and restoration of alluvial forests and bog woodlands in Brandenburg (North-East Germany). Project sites are located in ten NATURA2000-areas within three riverine systems. The project aims to protect, stabilize and develop bog woodland and alluvial forests in their natural characteristic including typical animal and plant species. This requires the establishment of a near natural water regime within the alluvial areas and forests as well as the associated waterways. For the conservation and stabilization of alluvial forests (\*91E0) it is planned to stabilize and improve the interdependence between the water course and its floodplain. This will be achieved by restoring natural gradients of watercourses, re-initiating meandering, or connecting dead channels. Silvicultural measures like the removal of foreign species will improve the habitat structure of \*91E0. In order to protect and restore internal water levels of bog woodlands (\*91D0) drainage ditches will be disabled and holdup devices, e.g. sheet pilings, will be installed. In addition, supporting measures will be implemented for re-establishing natural habitat structures of \*91D0, including forest conversion (into deciduous and mixed forests) and the introduction of certain plant species.

## ECOLOGICAL RESTORATION OF THE UPPER STREAM ØLE Å, BORNHOLM, DENMARK

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Denmark is no exception when it comes to the general lack of effect evaluations in nature management projects; especially before-after comparisons are scarce. On the Baltic island Bornholm, a scientifically driven ecological restoration project was conducted along the upper 3.5 km of the stream Øle Å. The stream is fed in a strictly protected calcareous wetland and runs for 4 km through a forest dominated by non-native Norway spruce (*Picea abies*), intensively managed for timber production. The dense plantations, sticking to the banks of the stream, are known to change driving environmental parameters like light, the hydrological cycle and soil properties, causing adverse effects on the ecological condition in the area. In the autumn of 2014, a buffer of approximately 20 m was cleared of spruces on both sides of the stream, while native trees – mainly willow, alder, birch and pine – were kept, leaving a mixed area for open-ended secondary succession. The project's objective is to develop and apply scientific methods for describing the ecological responses, aiming at provisioning documented knowledge and experiences for use in future initiatives. Building on a BACI design (Before-After-Control-Impact), the whole ecosystem was intensively monitored prior to and after the intervention, including physical properties like nutrient dynamics in the soil and water flow, biodiversity indices of several taxonomic groups, and social parameters like stakeholder interactions.

## RESTORATION AND CONSERVATION OF WETLANDS IN A TSUNAMI DISASTER ZONE AFTER THE 2011 TOHOKU EARTHQUAKE

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A magnitude 9.0 earthquake struck the Pacific Ocean off northeastern Japan on 11 March 2011. The subsequent tsunami wrought destruction on a massive scale. Kesenuma City was one of the most heavily damaged regions in Miyagi Prefecture, where more than thousand people were killed by the tsunami and subsequent fires, and 220 people are still missing. To provide ecological information that may be relevant for developing policies for sustainable reconstruction of areas affected by the tsunami disaster, the distribution of organisms and environmental changes in a disaster area of Moune, which is a small fishing village in Kesenuma City, after the 2011 tsunami were investigated. We recorded the number and location of egg masses of the Tohoku salamander *Hynobius lichenatus*, which is an endangered species, and the distribution of aquatic insects in eight wetlands named from A to H, whose area is 6,133, 4,288, 2,023, 12,323, 1,539, 1,331, 4,166 and 3,157 m<sup>2</sup>, respectively. The total number of egg masses were 747, 131, 143 and 241 in 2012, 2013, 2014 and 2015, respectively. In the first spring after the tsunami 143 of 747 egg masses died. Especially in wetland C, 97% of egg masses died in the spring of 2012 due to the high concentration of salt. Then, no egg mass was recorded in 2013. In wetland A, the number of egg masses dramatically decreased from 346 in 2012 to 43 in 2015, because of the land reclamation for farmlands. Wetland B was also reclaimed in the fall of 2014. However, a vegetated canal and pond were restored, then the number of egg masses increased from 35 in 2014 to 78 in 2015. Forty-two dragon and damsel fly species were recorded and the number increased from 2012 to 2015. However, most wetlands have been already reclaimed and destroyed by the reconstruction of road and farmland since 2014. In conference, we will introduce the results in spring of 2016 and the debate of conservation in the disaster zone.

# SESSION 3 – RESTORATION OF PEATLANDS FOR CLIMATE CHANGE MITIGATION AND ADAPTATION

**Chairs: Matthias Drösler, Annette Freibauer**

Restoration of peatlands for mitigation of and adaptation to climate change - scientific challenges and strategies for implementation At COP<sub>21</sub> in Paris the goal of limiting climate change well below 2 °C of pre-industrial levels was adopted. This goal is not only achievable with technical measures. Land-use and land-management strategies are of rising importance. Among all ecosystems peatlands drained for agriculture hold the highest emissions up to 35 t CO<sub>2</sub>eq per year. Due to the long-term drainage history Europe has high emissions from peatlands globally and here German peatlands are first with about 45 Mio t CO<sub>2</sub>eq per year. Hence restoration and rewetting of peatlands is key for climate change mitigation and adaptation.

This session has three major aspects: (1) State of the art of GHG balances: What do we know, what are the gaps for future measurements and modelling, how to prognosticate emission change by restoration activities etc.? (2) Upscaling of GHG emissions: What are the major drivers, how to bridge the gap between process understanding and upscaling? (3) Implementation of emission-reduction strategies: Best practice examples for projects covering policy programs, planning, funding (including certificates), monitoring of GHG-emission reduction by peatland restoration and linkages to biodiversity. This session brings together peatland scientists of a broad range of expertise in rewetting and restoration of peatlands to discuss the state of the art and to identify future research needs and implementation strategies that will help us to manage peatlands for the welfare of humans, biodiversity and the climate.

## GREENHOUSE GAS BALANCES IN LOW-PRODUCTIVE DRAINED BOREAL PEATLANDS – IS CLIMATE-FRIENDLY MANAGEMENT POSSIBLE?

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Five million hectares of peatlands have been drained for production forestry in Finland. About 20% of that, i.e. one million hectares, have been estimated to be so low-productive that the profitability of keeping them in forestry is questionable. At the same time, drainage has introduced changes in the ecosystem functions of these peatlands, including fluxes of greenhouse gases. Options to manage such peatlands include for example (1) no measures, i.e. leaving the drained peatlands as they are, (2) increasing intensity by e.g. repetitive fertilisations, and (3) restoration back to functional peatlands. Here we estimate the greenhouse gas impacts of these three management options. We collected GHG and organic carbon flux data from 50 low-productive peatlands under these management options over two years 2014–2015. Gas fluxes (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O) were measured with closed chambers. Litter production rates of different plants above and below ground were estimated using litter traps (trees), biomass sampling (roots), through-grow nets (mosses), allometric biomass models (other vasculars) and published turnover rates (roots, other vasculars). Characteristics for estimating tree stand biomass increment were measured at each site from circular sample plots. In this presentation we will estimate the GHG impacts for the different management options, and aim to find the most climate-friendly options for the management of low-productive peatlands in the short- and long-term. This work was funded by Life+ LIFE12/ENV/FI/150.

## SHORT ROTATION FORESTRY ON DRAINED AND REWETTED PEATLAND – OPTIONS FOR CLIMATE CHANGE MITIGATION

Martina Schlaipfer, Alicia Fuertes Sánchez, Matthias Drösler

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Over 95% of German peatlands have been drained primarily for agricultural use, resulting in estimated greenhouse gas (GHG) emissions of 47 million tons per year. In compliance with the regulations for the Bavarian Energy Turnaround, former grassland on a drained fen near Rosenheim, Bavaria, is now used for short rotation forestry (SRF). The study aims at determining how water table (wet vs. dry), tree species (poplar vs. alder) and method of establishment influence GHG emissions from SRF on peatland. Understory GHG fluxes are measured using closed-chamber methods. Allometric methods are employed to estimate tree carbon sequestration. The water table, which had been lower than desired around the wet sites in 2013 and 2014 ( $-36.4 \pm 6.1$  cm), rose after sheet piling was installed there in December 2014 ( $-17.9 \pm 3.3$  cm). Early results suggest that ploughing for SRF establishment has a limited effect on understory GHG emissions, but a distinct impact on tree productivity. Meanwhile, both tree species and water table seem to significantly influence understory GHG emissions. While  $\text{CO}_2$  emissions varied between different variable combinations even before the sheet piling was installed,  $\text{CH}_4$  and  $\text{N}_2\text{O}$  balances were similar for most sites. In 2014 only the wet alder site showed higher  $\text{CH}_4$  and very low  $\text{N}_2\text{O}$  fluxes, likely as a result of having the highest water table. First results from 2015 suggest a reduced climatic relevance of the wet sites due to the risen water table.

## SPACE FOR TIME-GHG BALANCE AS INDICATOR FOR RESTORATION SUCCESS OF A PRE-ALPINE BOG

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Peatlands store about ten times more carbon per area than mineral soils, because of frequently anaerobic conditions under pristine situations. But this carbon stock can be oxidized and released as carbon dioxide ( $\text{CO}_2$ ) to the atmosphere after drainage of peatlands in a short time. Our study focused on Greenhouse Gas (GHG) exchange ( $\text{CO}_2$ ,  $\text{CH}_4$  and  $\text{N}_2\text{O}$ ) along a gradient of restored to degraded sites in two research areas (Schechenfilz and Mooseurach) in the pre-Alpine region of southern Germany. The GHG exchange was investigated from 05-2012 to 05-2016, using the closed chamber method. It was determined that across all sites, in 2012, the annual sum of modelled net ecosystem exchange (NEE) and annual  $\text{CH}_4$  exchange rates ranged from  $-189$  to  $215 \text{ g CO}_2\text{-C m}^{-2}\text{a}^{-1}$  and  $0.38$  to  $40 \text{ g CH}_4\text{-C m}^{-2}\text{a}^{-1}$ . In 2013, similar flux patterns were observed, with a sum of modelled NEE and sum of  $\text{CH}_4$  fluxes ranging from  $-258$  to  $196 \text{ g CO}_2\text{-C m}^{-2}\text{a}^{-1}$  and  $0.35$  to  $27 \text{ g CH}_4\text{-C m}^{-2}\text{a}^{-1}$ . These balances were clearly influenced by vegetation cover. Drier sites had higher ecosystem respiration (Reco) than wet sites. Also, if GWP is considered,  $\text{CH}_4$  release was compensated by uptake of  $\text{CO}_2$  especially where the average annual water table is near the surface, which could be attributed to restoration succession processes. In degraded sites, the combination of both the relatively drier surface and the appearance of non-typical bog plants resulted in significant differences in GHG fluxes compared to restored sites. Generally, water table influenced the restoration success and the success towards climate mitigation.



## NITROUS OXIDE REDUCTION MEDIATES AGAINST EMISSIONS FROM ARABLE ORGANIC SOIL

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Emissions and below-ground distribution of nitrous oxide (N<sub>2</sub>O), water table (WT) depth and soil mineral N were monitored during 10-wk periods in spring and autumn 2015. Four sites were distributed along a gradient across a raised bog in Northern Denmark with shallow peat. Two sites had rotational grass and two sites a potato crop; one grass and potato site were paired. Emissions of N<sub>2</sub>O were determined weekly using static chambers. At the paired site N<sub>2</sub>O emissions were also determined using Li-Cor 8100 automated chambers interfaced with a N<sub>2</sub>O Isotopic Analyser (Los Gatos Research). Soil concentration profiles of N<sub>2</sub>O were determined at 5, 10, 20, 50 and 100 cm depth using passive diffusion samplers. Soil mineral N at 0–50 cm depth and WT were determined at sampling. Soil N<sub>2</sub>O concentrations in peat under grass were always low, but under potato there was consistent N<sub>2</sub>O accumulation coinciding with WT depth. However, there was evidence for extensive N<sub>2</sub>O reduction in the capillary fringe, mediating emissions. An inverse relationship between diurnal temperature and time of peak N<sub>2</sub>O emissions provide additional evidence for N<sub>2</sub>O reduction during transport towards the surface. Preliminary data show a 90% decline in chemical reduction capacity below the depth of peak N<sub>2</sub>O accumulation, indicating that reactive organic matter is a limited resource. Raising the WT depth could reduce N<sub>2</sub>O retention and increase emissions if soil N status remains high.

## AQUATIC CARBON EXPORT AND WATER QUALITY IN RELATION TO FOREST TO BOG RESTORATION MANAGEMENT

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Forest to bog restoration is a land management practice where peatlands afforested with non-native conifers are restored to open bog by removing the trees and blocking drainage ditches. This management is carried out with the aim to re-create healthy blanket bog habitat which also functions to sequester atmospheric carbon. In peatland landscapes the loss of dissolved organic carbon (DOC) through water is an important component of the carbon budget. Forest to bog restoration, which leads to a rise in the water table and decomposition of brash material, may therefore affect aquatic carbon export. The rivers receiving blanket bog drainage are of high quality, with low metal, nutrient and sediment concentrations making them important habitats for Atlantic Salmon. Thus, it is essential to understand the effect of forest to bog management on water quality of receiving streams and rivers. This project investigates the short term effect (0–1 year post management) of forest to bog restoration management on water quality and aquatic carbon export. This is achieved by comparing streams from catchments undergoing forest to bog management with control streams in an open bog and afforested catchment. We found increasing aquatic carbon concentrations following restoration. We also observed clear seasonal controls on aquatic carbon concentrations and export. Future changes in temperature and storm patterns may therefore impact these processes.

## THE FIRST OUTCOMES OF EXPERIMENTS ON PEATLAND RESTORATION FOR CLIMATE CHANGE MITIGATION AND ADAPTATION IN STEPPE AND ARCTIC REGIONS OF RUSSIA

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Experiments on peatlands restoration for climate change mitigation and adaptation were carried out within pilot areas of the ClimaEast EU funded project in the steppe region (Republic of Bashkortostan) and European arctic area (Nenetsky Autonomus Okrug) in Russia. Special techniques were developed to prevent permafrost thaw and enhance carbon accumulation for the arctic area. Peatland restoration in the steppe region was undertaken in conditions of clear shortage of water. Detailed hydrological modelling was carried out to support ecological restoration activities in steppe. The development of specific restoration techniques for those marginal conditions for peatland distribution are considered adaptation measures. The input to climate change mitigation is assessed by the study of carbon accumulation rate and fluxes both by emissions and dissolved organic carbon (DOC) in natural and disturbed peatlands; evaluation of losses of carbon due to peatlands transformation; and modelling of potential gains of carbon due to the restoration activities.

## THE EXPERIENCE OF LARGE SCALE PEATLAND REWETTING PROJECT IN RUSSIA FOR CLIMATE CHANGE MITIGATION

Andrey Sirin<sup>1</sup>, Tatiana Minayeva<sup>1,2</sup>, Hans Joosten<sup>3</sup>, Gennady Suvorov<sup>1</sup>, Dmitry Makarov<sup>1</sup>, John Couwenberg<sup>3</sup>, Arina Schrier<sup>2</sup>, Aleksandr Maslov<sup>1</sup>, Maria Medvedeva<sup>1</sup>, Anna Vozbrannaya<sup>1,4</sup>, Anastasiya Markina<sup>1</sup>

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Large areas of peatlands drained for peat extraction and agriculture in the European part of Russia were left abandoned, resulting in CO<sub>2</sub> emissions and high fire risks. Rewetting could return peat soils to their original water-logged state and prevent their vulnerability to fires and peat oxidation. The project “Restoring Peatlands in Russia – for fire prevention and climate change mitigation” financed under the International Climate Initiative (ICI) by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is aimed to prove effect for climate change mitigation of 73 thousand hectares of fire vulnerable transformed peatlands rewetted under a governmental programme (2010–2013) in the Moscow Province after severe fires in 2010. The project task is to test available methods of greenhouse gas (GHG) reduction evaluation, including methodologies for GHG inventories under the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC), and to assess the effectiveness of large scale rewetting for climate change mitigation.

# SESSION 4 – TOWARDS ENHANCING ECOSYSTEM RESILIENCE IN FENS

**Chairs: Wiktor Kotowski, Kristian Hassel, Agata Klimkowska**

Resilience of fen ecosystems becomes increasingly important in unstable world where neither natural (e.g. climatic) nor socio-economical (e.g. management) mechanisms supporting ecosystem functions can be assured. Resilience of an ecosystem is rarely the main aim of restoration. More often the target is biodiversity or services that an ecosystem provides. However, sustaining the restoration outcomes in future or the costs and options for ecosystem maintenance may largely depend on the resilience of restored systems. Intact fen ecosystems are maintained by severe environmental stresses and can be stable for a long periods of time (also under changing climate), which is documented in peat profiles throughout Holocene. When disturbed by human land use, they lose their natural resilience and their persistence becomes dependent on social systems (driven by demand for animal fodder or nature management). Within this session we would like to discuss: (1) mechanisms of resilience in natural fens, (2) possibilities to recreate those mechanisms by restoration measures, and (3) possible trade-offs between restoration of resilience and other objectives for restoration. The session consists of contributions from the members of the project MIRACLE (<http://www.biol.uw.edu.pl/miracle/>). Additionally, there are speakers with presentations addressing the topic of mire resilience and its links with restoration theory and practice.

## WHAT IS RESILIENCE IN MIRES AND HOW CAN WE IMPROVE IT IN RESTORATION PROJECTS?

Wiktor Kotowski, Łukasz Kozub, Marina Abramchuk, Klara Goldstein, Tomasz Wyszomirski

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Natural fen ecosystems maintained by severe environmental stresses can be extremely resilient, which is documented in peat profiles throughout the Holocene. Nevertheless, disturbed by humans they lose their natural resilience and their persistence becomes dependent on social systems (demand for animal fodder or active nature conservation). Within the framework of the project „Mires and climate: towards enhancing functional resilience of fen peatlands”, we wanted to deepen our understanding of functional mechanisms of resilience of fen mires, both natural, connected with eco-hydrology, geochemistry and ecosystem structure, and social, related to management and restoration practices. To achieve that objective, we adopted a multidisciplinary and multi-site approach, integrated with the use of functional diversity (FD) and functional trait spectra as predictors of ecosystem functioning and resilience. Preliminary results of the project confirmed our hypothesis that resilience of natural fen ecosystems is maintained by environmental stresses deriving from favourable eco-hydrological and geochemical conditions. However, management practices seem to release the abovementioned stresses, making the managed ecosystems more dependent on social resilience. Translating these findings into restoration practices can mean that our targets should be ecosystems with higher levels of environmental stress, even though it can mean less functional and species diversity during initial stages of ecosystem recovery.

## PALAEOECOLOGICAL REFERENCES FOR RESTORING RESILIENT FENS

Ewa Jabłońska<sup>1</sup>, Dierk Michaelis<sup>2</sup>, Klara Goldstein<sup>1</sup>, Wiktor Kotowski<sup>1</sup>

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Rich fens (mires dominated by sedges and brown mosses) are among the most threatened ecosystems in Europe, thus of high conservation priority. To enhance success of conservation and restoration efforts, understanding of mechanisms of mire resilience is beneficial. As rich fens used to persist in the past for millennia, we can read from the peat profiles information on determinants and drivers of their resilience. Based on a literature review, we compiled a database of 14C-dated and macrofossil-analysed peat profiles from European mires containing rich fen stages. Peat samples were treated as records of former plant communities which were assigned to vegetation types. Functional traits were used to describe ecological features of ancient plant communities. Based on delineation of reconstructed mire vegetation types within each profile and weighted means of functional traits for each community, we distinguished stability periods from phases of abrupt shifts. The occurrence of shifts in mire development was assessed in relation to external environmental factors. We described spectra of functional traits present during stable rich fen stages, symptoms of approaching mire shift, and fluctuations in species and functional diversity during the resilient mire phase. External drivers of fen resilience appeared to be its hydro-genetic type and catchment hydrology, which is influenced by changes in regional vegetation cover (land-use and/or climatic changes).

## ARE WE RESTORING RESILIENT FENS? – AN OVERVIEW OF THE RESULTS OF FEN RESTORATION PROJECTS BY REWETTING AND TOPSOIL REMOVAL

Agata Klimkowska<sup>1,2</sup>, Klara Goldstein<sup>1</sup>, Wiktor Kotowski<sup>1</sup>, Tomasz Wyszomirski<sup>1</sup>, Mateusz Wilk<sup>1</sup>, Marina Abramchuk<sup>1</sup>, Mateusz Grygoruk<sup>3</sup>

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Functioning of ecosystems depends on and is expressed by plant functional traits (PFT), which therefore make a powerful tool for evaluating the effects and effectiveness of restoration. In fens, functional diversity analysis allows to assess operation of environmental filters, showing whether we improve the potential of fens to stay functional and stable. We applied this approach to data from restoration initiatives in Western and Central Europe. Data from vegetation monitoring, on species composition and abundance from permanent plots were gathered from ca. 30 projects. The duration of monitoring represented mostly 10–15 years after restoration actions (all together above 500 data plots). The data set was highly diverse, putting some constraints on analysis. We used trait databases to describe plant species and applied quantitative methods of comparisons. In reference fens, the filtering of PFT indicated importance of anoxia and nutrient stresses, which become relaxed after drainage and nutrient enrichment. Restoration actions are meant to reinstall the major abiotic stresses. Restoration resulted in functional composition more similar to the reference mires, but changes over time are often not directional and set-backs occur. Restoration by rewetting and by topsoil removal shifts PFT spectra towards references, but the effects differ and target values are approached only for a few indices. When PFT values indicate re-establishment of high-stress conditions, plant assemblages are functionally more convergent and less species-rich than reference fens. This shows a potential trade-off between optimising fen restoration to reach high species diversity and the goal to re-install stressors needed for keeping fens in a resilient state.

## WHERE TO RESTORE RESILIENT FENS? STUDY ON GROUNDWATER RECHARGE IN THE EUROPEAN PERSPECTIVE

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Groundwater recharge plays a crucial role in development and stability of fens. The main goal of our study was to assess the magnitude of changes in groundwater recharge estimation resulting from modelled changes of the landscape and climatic features in >300 fens located in Poland, Germany, The Netherlands, Sweden, UK and Norway. In our approach we (1) delineated the most probable extents of catchments of particular fens analysed, (2) assumed hypothetical and the most probable changes of land cover within these catchments, (3) assumed the most probable ranges of climatic changes, (4) developed a GIS-based groundwater recharge calculation algorithm to be applied in the study, (5) calculated groundwater recharge in multiple probable combinations of landscape and climatic conditions, and (6) revealed whether climate or landscape changes were the dominant factors influencing groundwater recharge in selected catchments. We revealed that in the case of 80% of fens analysed, groundwater recharge in the catchment-scale was strongly related to climatic features whilst in the remaining 20% only the specific combination of climatic and landscape features results in changing groundwater resources. We also revealed that groundwater recharge in certain fens did not change much in variable modelled landscape-climatic conditions, which may be considered a prerequisite of fens resilience towards hydrological stressors such as changing groundwater resources.

## SPECIES COMPOSITION IN BOREAL RICH FENS – THE ROLE OF NUTRIENT LIMITATION AND MANAGEMENT

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Plant species composition in boreal rich fens is largely controlled by water level and soil chemistry, which control the amount of nutrients made available to the plants. Climate and management interact with these factors. In a 15-year full-factorial NPK fertilization experiment carried out in a nutrient poor rich fen lawn community influenced by spring water at Sølendet, Central Norway (62°40' N, 11°50' E), increased availability of both N and P led to reduced species diversity caused by a few tussock-forming grasses outcompeting other species, especially bryophytes. In plots receiving N, the few species able to benefit from the added N were those that were common prior to the experiment, and they outcompeted species with scattered occurrence. Increased availability of P led also to considerable species turnover, but not to reduction in species diversity, and bryophyte diversity increased. The increase in bryophytes is explained by their association with N-fixing cyanobacteria, suggesting that P limitation is more common among bryophytes, which enable them to utilise the added P when vascular plants are less dominating. We hypothesise that both N and P limitation are vital for the maintenance of high species diversity in boreal rich fens due to the large species pool of vascular plants adapted to N limitation, and that P limitation controls bryophyte diversity. Increased knowledge of natural processes and management measures that affect nutrient dynamics in boreal rich fens are therefore vital in order to understand the resilience of these systems to changes in temperature and moisture regimes. This is important knowledge in our attempt to improve restoration and management of functional fen systems.

## PATTERNS AND DETERMINANTS OF LONG-TERM CHANGE IN BOREAL FEN VEGETATION

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In this presentation, we assess the resilience of boreal fen vegetation to climate change at Sølendet and Tågdalen in central Norway. The original species composition (1967–1986) is compared with that of the corresponding unmown and mown plots of the most recent re-survey (2012–2015) at 17 localities at Sølendet and 13 at Tågdalen. Different mowing regimes have been applied since the 1980s to permanent plots (mostly 12.5 or 25 m<sup>2</sup>). We analyse changes in diversity, cover of taxonomic groups (trees, shrubs, forbs, graminoids, mosses and liverworts) and species traits, then link vegetation change to measured and modelled environmental change. These changes were more dramatic at Sølendet (inland) than Tågdalen (coastal), suggesting that boreal fens may be more resilient to climate change in oceanic than in continental environments. The magnitude of change in species composition was much greater at the margins than in the expanse of the fen, and although mowing may not affect resilience, this practice can result in loss of diversity and heterogeneity in the vegetation. We discuss the implications of these results for informing restoration decisions that will optimise the resilience of fen vegetation, in particular whether mowing should be considered as an integral tool in the restoration process.

## IMPACT OF LARGE TRACKED MOWERS ON VEGETATION STRUCTURE AND FUNCTIONAL PLANT DIVERSITY OF FENS IN THE BIEBRZA NATIONAL PARK

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Drainage and eutrophication caused that most treeless fens lost their natural resilience and became dependant on mowing, which was recommended as a conservation measure. Early results indicated that application of tracked mowers on fens resulted in a more homogeneous micro-topography conducive to clonal semiaquatic herbs. Continuing the experiment, we assessed how repeated tracked mowing in Biebrza National Park affected selected parameters of the fen vegetation structure and functional plant diversity. In 2015 we compared three treatments in six blocks of plots: 1) never mown with tracked vehicles, 2) neglected for 5 years after tracked mowing, 3) mown with tracked machinery twice or thrice during the last 5 years. Application of confidence intervals for means allowed assessing of the size of the effects for the mowing regimes. We found out that mowing with tracked vehicles caused: flattening of the fen surface, reducing height and cover of tussocks; decreasing cover of sedges and increasing cover of forbs. Cover of litter as well as functional divergence decreased, while cover of herbs, functional richness, and specific leaf area increased on the mown sites. The size of the effects varied due to tracked mowing frequency. The results should be taken into account during adaptive conservation management of fens.

# SESSION 5 – FIRE IN ECOSYSTEM DYNAMICS AND RESTORATION

**Chairs:** Orsolya Valkó, Béla Tóthmérész

Fire is a major driver of ecosystem dynamics in many parts of the World. Fires in the form of natural wildfires and controlled burning actions alter the abiotic environment, resource availability and population dynamics, which all lead to changes in community composition. There are numerous examples on the use of prescribed burning in the management of fire-prone ecosystems, such as boreal forests, prairies, heathlands and Mediterranean shrublands. In less fire-prone ecosystems, there are debates on the application of prescribed burning in biodiversity conservation and restoration. Some conservationists highly welcome prescribed fire, while others are strongly against it. These contrasting attitudes are likely due to the lack of proper scientific knowledge on both short- and long-term effects of fires in these ecosystems. The overall aim of the special session is to present best practices and future perspectives of fire management and to highlight the potential of prescribed burning in ecosystem restoration. We welcome presentations from theory and practice on the effects of fire on ecosystems, on historical and current fire regimes and on conservation and restoration projects that applied prescribed burning. The session is associated with the Eurasian Fire in Nature Conservation Network (<http://www.fire.uni-freiburg.de/programmes/natcon/EFNCN.html>).

## USE OF PRESCRIBED FIRE IN NATURE CONSERVATION, LANDSCAPE MANAGEMENT AND FORESTRY – EXPERIENCES AND PERSPECTIVES FOR GERMANY

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With the exception of few regions, extended areas of Europe are faced by the abandonment of agriculture and pastoralism. This trend of land-use change is threatening the sustainability and survival of open cultural landscapes with their habitats for open-space dependent species. Abandoned lands are undergoing rapid succession. Substitution measures, which are practiced in some places to encounter succession and to maintain the open space habitats, include subsidized mechanical treatment or targeted grazing but are limited by the sheer magnitude of land area to be managed and by the rapidly increasing costs. Since the 1990s the use of prescribed fire is increasingly tested and applied to maintain open-landscape habitats. The application of prescribed fire on active and abandoned military areas, which often have a high conservation value and are classified as Natura2000 sites, are limited due to the contamination by unexploded ordnance. Technical solutions have been developed to encounter these threats. The paper is summarizing the experiences, progress and perspectives of the use of prescribed fire for the maintenance of biodiversity of the open cultural landscapes of Germany. Furthermore, the state-of-the art in using prescribed fire in landscape management and in forestry are discussed.

## TO BURN OR NOT – A PERSPECTIVE ON BRITISH MOORLANDS

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British moorlands hold an almost unique place in burning research. Prescribed burning has been carried out for centuries, originally for sheep grazing but more recently it is implemented mainly for grouse shooting. Much of the moorland vegetation grows on deep peat and recently there has been much debate about whether it should be continued. The essence of the debate is that UK peatland contains a very large carbon store and also acts a means of retaining water and assisting with flood relief. Prescribed burning will release carbon to the atmosphere and there is some evidence that it can also discolour water, adding to purification costs when used for human consumption. However, the ecosystems are fire-adapted and where no prescribed burning takes place there is a build-up of biomass, an ever increasing fuel load. Here, I will discuss some of the pros and cons of prescribed burning using data from a long-term manipulative experiments. I will consider effects on vegetation, regeneration potential as well as impacts on peat and illustrate part of the dilemma using data from a predictive model which assess the relative impacts of prescribed burning at different rotations on carbon balance, including the effects of periodic wildfire.

## RESTORING A GRASS-DOMINATED ECOSYSTEM FOR A SALAMANDER, A LILY, AND A WOODPECKER: A CASE STUDY OF FIRE IN THE APALACHICOLA NATIONAL FOREST

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The longleaf pine (*Pinus palustris*) ecosystem is dependent on frequent, low-intensity fires to maintain an open longleaf canopy and grass-dominated groundcover. Apalachicola National Forest (ANF, Florida, USA) has about 120,000 ha of upland pine forest that historically burned every 2–3 years. We discuss three rare species found in ANF that are acutely affected by fire management: red-cockaded woodpecker (*Picoides borealis*) requires extensive areas of pine-dominated habitat with significant components of older trees and grassy understory; frosted flatwoods salamander (*Ambystoma cingulatum*) needs open ephemeral wetlands for its breeding sites; and Harper's beauty (*Harperocallis flava*) occurs in ecotones between pine uplands and wet savannas or wetlands. ANF fire management program is one of the most active in the National Forest system, but the fire interval on most of the forest is closer to 4–5 years. Preliminary results of a recent study have shown that wetland shrubs are advancing into the uplands and filling up ephemeral wetlands presumably due to insufficient fire frequency and intensity. Highest productivity of red-cockaded woodpeckers occurs in pine woodland with grass-dominated understory maintained by frequent fires. More innovative practices need to be developed and implemented to stabilize population decline in the salamander and lily. Specifically, adaptive application of fire by season and mechanical or herbicides may provide management solutions.



## SUPPORTING BIODIVERSITY BY PRESCRIBED BURNING IN DRY GRASSLANDS - A MULTI-TAXA APPROACH

Orsolya Valkó<sup>1</sup>, Balázs Deák<sup>1</sup>, Tibor Magura<sup>2</sup>, Péter Török<sup>2</sup>, András Kelemen<sup>1</sup>, Katalin Tóth<sup>2</sup>, Roland Horváth<sup>2</sup>, Dávid Nagy<sup>1</sup>, Zsuzsanna Debnár<sup>1</sup>, György Zsigrai<sup>3</sup>, István Kapocsi<sup>4</sup>, Béla Tóthmérész<sup>1</sup>

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We studied the effects of prescribed burning in dry alkali grasslands of high conservation interest. Our aim was to test whether dormant-season prescribed burning can be a feasible conservation measure in these grasslands. We selected six sites in Hortobágy National Park (Hungary): in November 2011, a prescribed fire was applied in three sites, while three sites remained unburnt. We studied the effects of burning on soil characteristics, plant biomass, vegetation composition and arthropod assemblages (isopods, spiders, ground beetles and rove beetles). Soil pH, organic matter, potassium and phosphorous did not change, but soluble salt content increased significantly in the burnt sites. Burning had several positive effects from the nature conservation viewpoint. Plant diversity and the number of flowering shoots increased, and the cover of the dominant grass *Festuca pseudovina* decreased in the burnt sites. Graminoid biomass was lower, while total, green and forb biomass were higher in the burnt sites. The key finding of our study was that prescribed burning did not decrease the abundance and diversity of arthropod taxa. Out of the most abundant invertebrate species, ten were not affected, one was negatively and one was positively affected by burning. Our results suggest that prescribed burning leaving unburnt patches can be a viable management tool in open landscapes, because it supports plant diversity and does not threaten arthropods.

## FOREST FIRES AND THE REGIONAL DISTRIBUTION OF BEETLES FAVOURED BY FIRE

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Modern forestry has dramatically reduced the amount and size of forest fires in northern Europe and several pyrophilic species are now threatened. Substantial efforts are put into control burns in forests Sweden, but the actual benefit of a an individual fire remains less clear, and there is room for optimizing both temporal and spatial occurrence of such conservation burns. We sampled insects attracted to smoke generated as an attractant at 21 sites in a forested region of SE Sweden. The catch was compared against recent (<15 yrs) forest fire statistics with the aim to relate the occurrence of species to temporal and spatial history of fires. Huge numbers of *Microsania* (Diptera) were attracted, but the catch was unrelated to fire history. Of eleven pyrophilic beetles, seven were positively correlated with recent forest fires, mostly at the smaller spatial scales (100–5000 m). The abundance of 17 beetles with unknown fire-dependency was also associated with recent forest fires. As the autecology of many of these species is not known, it is possible that they too might be favoured by substrates created by fires. Conclusion: Conservation burns that are strategically placed, both temporally and spatially, can help to increase the conservation benefit of forest fires to conserve both fire-dependent and fire-favoured insects.

## SPOTLIGHT ON BEECH (*FAGUS SYLVATICA* L.) FIRE ECOLOGY

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Global warming will increase fire hazard in historically non fire-prone regions. The large fires affecting beech forests of the SW Alps in 2003 serve as an example. This raises questions on post-fire measures to re-establish ancestral ecosystem services. In order to base measures on ecological evidence, resistance and resilience processes were studied in 40 beech stands (300 plots à 200 m<sup>2</sup>) burnt between 1970–2013 and surveyed between 2010–2014. Results of this retrospective (space for time substitution) approach show: (1) Beech mortality, if any, occurs within 20 yrs. since fire. Post-fire mortality depends on burn severity and impact such as damaged tissue across the stem and fungi infestation. (2) Seed production in mast years declines only where burn severity is high. Intermediate burn severity favours seed germination and seedling establishment by consuming the litter and increasing incident light. (3) Regenerating beeches dominate in the mid-term over other trees, and profit from partial canopy openings. Rapid beech mortality following high severity may favour stand-forming ferns, shrubs, grasses that outcompete beech regeneration for long. To promote beech regeneration, surviving trees providing seeds and shelter should be left at place, even if highly damaged. To improve mechanical stand stability, beech should be felled timely (3-5 yrs) before wood decaying fungi establish and in coincidence with mast years. Deadwood provided by gradual beech mortality should not be removed.

## ECOLOGICAL ROLE OF FIRE IN THE CENTRAL EUROPEAN *PINUS SYLVESTRIS* FORESTS

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In Europe, fire is considered to be an integral part of forest dynamics mainly in Mediterranean and Fenno-Scandinavian regions. In temperate forests of Central Europe, the ecological role of fire was traditionally neglected despite documented frequent fire occurrence. Firstly, we aimed to reveal the drivers of wildfire occurrence in the landscape of the Czech Republic. For this purpose, we performed spatial analyses based on officially reported data on wildfire statistics and GIS layers of human, biotic and abiotic environmental factors. According to our results, the markedly fire-prone habitat appeared to be the semi-natural *Pinus sylvestris* dominated forests of sandstone rocky areas of specific rugged relief. Afterwards, we focused on the effect of wildfire on long-term dynamics of such pine forests, using vegetation sampling method with a space-for-time substitution design. We observed the spontaneous post-fire development of the vegetation composition and diversity, the role of fire severity, the ability of tree species to resist the fire, and asked whether fire disturbance can contribute to preservation of the pine-dominated forests in the region. We found that forest vegetation is resilient to the fire similarly to boreal forests, as it spontaneously developed into pre-disturbance-like state in ca. 140 years. However, a continuous shift towards stands with higher proportional abundance of more shade-tolerant and fire-sensitive tree species than *P. sylvestris* was found in late post-fire successional phases. Periodic fire disturbance occurring ca. once in 200 years thus seems to be a factor maintaining *P. sylvestris* dominated forests in the Central European sandstone landscapes in the long run.

## **A MODELLING APPROACH TO REDUCE CARBON EMISSIONS IN *CALLUNA VULGARIS* MOORLANDS: WHEN PRESCRIBED BURNING AND WILDFIRES INTERACT**

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A present challenge is to optimize management techniques so that ecological services are maximized and C emissions minimized. We model the effects of different prescribed-burning rotation intervals and wildfires on C emissions in British moorlands. Biomass-accumulation curves from four *Calluna*-dominated ecosystems along a north-south gradient were calculated and used within a matrix-model based on Markov Chains to calculate above-ground biomass-loads, and annual C losses under different prescribed-burning rotation intervals. We also assessed the interaction of these parameters with an increasing wildfire return interval. Litter accumulation patterns varied with differences between northern (colder and wetter) and southern sites (hotter and drier). The *Calluna*-biomass accumulation patterns were determined by site-specific conditions. The optimal prescribed-burning rotation interval for minimizing annual carbon losses differed between sites: for northern sites it was between 30 and 50 years, whereas for southern sites a hump-backed relationship was found with intervals either 8–10 years or 30–50 years. Increasing wildfire frequency interacted with prescribed-burning by both increasing C emissions and modifying the optimum burning interval for C minimum emission. This highlights the importance of studying site-specific biomass accumulation patterns with respect to environmental conditions for identifying suitable rotation intervals to minimize C losses.

# SESSION 6 – GRAZING AS A BEST PRACTICE RESTORATION TOOL

**Chairs: Sabine Tischew, Norbert Hölzel, Péter Török**

Based on the outcome of our special session in Oulu 2014 we are aiming at a systematic review of the role grazing practices can play as exclusive restoration measure or as part of more complex restoration procedures. Presentations are dealing with possibilities and limitations of grazing management in overcoming abiotic and biotic restoration thresholds, such as eutrophication, shrub and grass encroachment, loss of habitat-specific plant and animal species or habitat fragmentation. We are particularly interested in studies which provide solutions for best practice approaches in complex habitat restoration after severe degradations combining grazing practices with additional measures to improve habitat quality. Comparisons between effects of different grazing practices (e.g. traditional migratory herding versus free-ranging and year-round grazing or different types of grazers) on functions and mechanisms of ecosystems as well as on target species and communities are also in focus of our session. Moreover, talks addressing the suitability of habitats and vegetation types for different grazing practices under consideration of constraints by animal welfare, e.g. by fodder supply are included. We also have invite speakers from policy and practice to discuss financial aspects and evaluate socio-economic sustainability of grazing, e.g. under the new framework of the Common Agricultural Policy in Europe. Outcomes of this session give background knowledge about functions and processes linked to different grazing practices and facilitate decisions on habitat management and restoration measures.

## EFFECTS OF YEAR-ROUND GRAZING ON THE VEGETATION OF NUTRIENT-POOR GRASSLANDS AND HEATHLANDS – EVIDENCE FROM A LARGE-SCALE SURVEY

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Year-round grazing by cattle and horses has recently become a common practice in conservation management in north-western Europe. Though many projects claim positive effects on vegetation development, evidence is still largely anecdotal. There are no comprehensive regional surveys allowing the detection of general patterns beyond single case studies. This applies even more to nutrient-poor sites where year-round grazing systems were only recently established and concerns about potentially negative effects on plant diversity are still prevalent. Hence, this study investigates the impacts of year-round grazing on plant species richness, species composition, and vegetation structure on nutrient-poor sites using a regional multi-site approach. Surveys were carried out at five different study sites in the diluvial plain of northwestern Germany and the Netherlands, comprising sand grasslands, dry grasslands, and heathlands. Results show overall positive effects of grazing: Plant species richness, the number of endangered plant species, and the proportion of open soil were increased significantly. Contrarily, green biomass, litter cover, vegetation height, and the cover of woody species decreased significantly. At grazed sites there were more small, light-demanding species than taller, mesophilic species. A distinct decrease of ruderal species and an increase of species following a competitive strategy was observed at abandoned sites. Based on broad regional evidence, we conclude that year-round grazing is a suitable tool for the restoration and management of open habitats on nutrient-poor sandy sites. Low sward biomass and poor nutritional quality raise, however, concerns about adequate fodder supply and animal welfare.

## RESTORING AND MANAGING LARGE SCALE SANDY GRASSLAND-HEATHLAND ECOSYSTEMS: COMBINING LARGE HERBIVORE GRAZING WITH SHRUB CUTTING AND HEATHER MOWING

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Since 2008, free-ranging year-round grazing with Heck cattle and Konik horses (stocking rate: 0.2 livestock units ha<sup>-1</sup>) has been established in a 800 ha sandy grassland-heathland ecosystem in the Oranienbaumer Heide (Saxony-Anhalt) to restore NATURA2000 habitats, which were severely degraded by increasing cover of bushgrass, heather degeneration, and shrub encroachment due to long-term abandonment. Shrub encroachment was reduced by cutting before grazing started. From 2008–2015 grazing effects were evaluated across different vegetation types by using before/after and with/without approaches on different survey scales (macroplots: 100 m x 100 m, microplots: 25 m<sup>2</sup>). After 7 years, grazing improved the habitat quality significantly; coverage of litter and bushgrass diminished in sandy grassland-heathland communities and bushgrass stands, whereas bare soil increased. These changes in vegetation structure resulted in a significant increase of plant species diversity. Grazing alone slowly enhanced the rejuvenation of heather, while an additional onetime mowing before implementation of grazing or the application of mineral licks led to a faster rejuvenation success. Cattle browsed frequently on *Prunus serotina*, resulting in significantly shorter average shoot length and 63% mortality after seven years of grazing. Economic sustainability has been ensured by agri-environmental schemes and the project reached a high social acceptance due to comprehensive public relation work. Concluding, year-round grazing combined with shrub cutting and onetime heather mowing offers an excellent tool to restore biodiversity in low productive large scale semi-open heathland landscapes.

## YEAR-ROUND HORSE GRAZING SUPPORTS TYPICAL VASCULAR PLANT SPECIES, ORCHIDS AND RARE BIRD COMMUNITIES IN A DRY CALCAREOUS GRASSLAND

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Large herbivores, such as robust horse breeds, are increasingly used to develop and maintain open habitats. However, their use on calcareous grasslands has rarely been tested. On the one hand, conservationists fear an unequal use of the pasture with partial abandonment, encroachment or reduced ground light conditions, as well as partial over-grazing with negative effects as soil erosion, latrines, grazing lawns, disturbance to the ground or shrub nesting bird species due to enhanced trampling, or impairment of typical plant species. On the other hand, it is well known that large herbivore grazing is an economical alternative where traditional sheep grazing is no longer profitable. From 2010–2014, we studied horse activity (Koniks), habitat parameters, and frequency of orchids and birds using a raster approach within a 90-ha year-round pasture (0.3 LU/ha). Vegetation composition was sampled on 25 m<sup>2</sup> plots from 2009–2014. All habitat parameters indicated a relatively equal horse utilization of the whole pasture and neither latrines nor partial abandonment were observed. After five years, shrub encroachment was restricted from 13.7 ± 17.0% to 12.0 ± 15.3%. Vegetation litter was reduced by 60% and the mean number of species typical for dry calcareous grasslands increased by one third on the 25 m<sup>2</sup> plots. The studied orchid species as well as the target bird species were not impaired by the grazers. The positive grazing effects, such as enhanced site conditions, seem to outweigh the potentially negative effects through trampling or grazing. We conclude that in large-scale calcareous grasslands, low-intensity year-round grazing with large herbivores is suitable for maintaining and even improving species diversity.

## USING KONIK POLSKI HORSES TO RESTORE EMBANKMENT PLANT COMMUNITIES IN THE RHONE VALLEY (SOUTHERN FRANCE)

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In the 1950s, 28 km of Rhone embankments that had been erected during the construction of the hydroelectric power station of Donzère-Mondragon (Vaucluse & Drôme, France), were planted with Black locust (*Robinia pseudo-acacia*) for stabilization. They have also been naturally colonized by plants and animals, and include today species with high patrimonial value. In order to limit shrub encroachment and to maintain the diversity of plant communities, Konik Polski horses were introduced in 2005, on 27 ha. This study aims to characterize the impacts of this grazing system on plant community composition, richness and diversity. In 2014, 2015 and 2016, the plant communities of the different vegetation patches were sampled in permanent quadrats. Their spatial organization and temporal dynamics were measured via aerial high spatial resolution photographs before and during the grazing period. Grazing pressure was estimated from aerial photographs by measuring the Tucker index (Normalized Difference Vegetation Index). Our results show that grazing significantly increases species richness ( $\alpha$ -diversity) and heterogeneity ( $\beta$ -diversity). Grazing also modifies species composition, enabling the installation of rare annuals in the most heavily grazed areas. The estimation of grazing pressure via the NDVI allows to connect grazing pressure with plant community dynamics. Monitoring will have to continue in the long term in order to optimize grazing management.

## SEASONAL VARIATIONS OF FODDER QUALITY AND AVAILABILITY AS CONSTRAINTS FOR STOCKING RATES IN YEAR-ROUND GRAZING SCHEMES

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Year-round grazing is increasingly applied for conservation management of grasslands. In such grazing schemes, periods of fodder shortage can occur in winter and early spring, but supplementary feeding is usually avoided. Hence, stocking rates have to be adjusted precisely to seasonal fodder availability for animal welfare reasons. We investigated the seasonal changes of biomass quantity and quality at four year-round pastures in northwest Germany. In total, 248 biomass samples were taken in spring, summer, fall and winter 2013 and 2014, and across different vegetation types. The samples were analysed for fiber contents and nutrients. Maximum grazing capacities for nutrient-rich and nutrient-poor pastures and different vegetation types were calculated for each season and for cattle and horses, separately. Overall, biomass quantity and nutrient contents were lower in nutrient-poor than nutrient-rich sites. Biomass quality varied less over the year at nutrient-rich compared to nutrient-poor sites. At nutrient-rich sites, a greater fluctuation in biomass quantity was measured over the year. Calculated grazing capacities were lowest in spring in both pasture types, but were limited by nutrient content at nutrient-poor sites and by biomass quantity at nutrient-rich sites. Especially for cattle, some nutrient contents of biomass were below requirements in winter and spring at nutrient-poor sites so that we rather propose grazing by horses or nutrient supplementation during the winter season. This study showed that adequate livestock nutrition under year-round grazing is possible, but that additional feeding or other measures might be necessary when pasturing very nutrient-poor habitats.

## PLANNING AND EVALUATION OF RESTORATIONAL GRAZING PROJECTS: PASTURE SUITABILITY AND ANIMAL MOVEMENTS

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In the context of restoration by re-introducing a grazing regime, efforts have to be consistent with animal production and animal welfare, given a lower suitability as pasture and reduced carrying capacity for livestock, making careful planning and monitoring inevitable. Management and restoration measures taken have to be communicated to all stakeholders (farmers, landowners) in advance, to reduce uncertainty and for being successfully in the end. In target areas for restoration, specially the availability of feed in sufficient quality is the first and most important factor. During a large-scale pasturing project (study area 11.2 km<sup>2</sup> of which 271 ha are pastured), located in the Austrian Alps (47.41° N, 13.78° E), based on previous work, an alpine pasture evaluation model was developed, to estimate feed quantity and suitability of a high pasture. The model is based on a combination of GIS and expert knowledge of plant production. Parameters necessary for the model are elevation, slope, animal species, types of pasture, defined in the model as forage types: rich pasture, rough pasture, dwarf shrubs and others, biomass and energy content of the different forage types and water availability. Results from the model provide a baseline for stocking rate and general pasture management, and accompany the planning phase. Data gained can easily be presented as maps to stakeholders and are a sound basis for pasture management plans. During pasturing, combined with GPS data from animals and spatially explicit calculation of the actual stocking rate, it is possible to estimate the still-available biomass and energy yield. The model represents a valuable tool for monitoring and evaluation of measurements.

## IS THE LIVESTOCK TYPE MORE CRUCIAL THAN GRAZING INTENSITY? CATTLE AND SHEEP GRAZING IN SHORT-GRASS STEPPES

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Sheep or cattle grazing are both vital options in biodiversity conservation of grasslands. In our study we compared the effects of traditionally herded cattle and sheep grazing on short-grass steppe vegetation under low-to-medium and high grazing intensities (0.5–1.5 and 2.5–3.0 animal units/ha) in Hungary. We included life form groups, start of flowering, total flowering period, rosette forming, specific plant heights, lateral clonal spreading, leaf dry matter content, leaf dry weight, specific leaf area, leaf area, and seed weights as individual traits into the analyses. We tested the following hypotheses: (1) Sheep grazing maintains a lower taxonomic and functional diversity, lower amount of forbs compared to cattle grazing. (2) Grazing effects are highly intensity-dependent and differences between cattle and sheep grazing are more pronounced at low grazing intensities than at high ones, because the selectivity of grazing decreases at higher intensities. We found lower taxonomic and functional diversity, and lower cover of forbs in sheep-grazed steppes compared to cattle-grazed ones. The livestock type had a significant effect on Shannon diversity and evenness. Most single trait indices were only affected by the livestock type. Most vegetation characteristics were significantly affected by livestock type, while much fewer intensity-dependent effects were confirmed. Our findings suggest that the selection of the livestock type is more crucial in biodiversity conservation and management than the adjustment of grazing intensity. For the highest variability of traits, grazing intensity should be carefully fine-tuned to the habitat type and the grazing animal.

## BIODIVERSITY IN LOW-INTENSITY PASTURES, STRAW MEADOWS, AND FALLOW OF A FEN AREA – A MULTITROPHIC COMPARISON

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Despite the Europe-wide protection of wetlands, knowledge on the performance of management strategies for biodiversity conservation across different trophic levels is still relatively scarce. Here, we compare old straw meadows with restored low-intensity pastures and with fallows in a fen area in the northern pre-Alps. We sampled biodiversity at three trophic levels including plants, leafhoppers and spiders. Plant species richness was significantly enhanced by grazing and mowing compared with fallows. In contrast, species numbers and abundances of leafhoppers and spiders were highest in pastures and lowest in meadows. Endangered plant species were relatively rare in the restored pastures, which were still nutrient-rich compared with meadows. Thus, land-use history can constrain restoration success for dispersal-limited plant species in the short term. Although fallow plots were poorer in terms of species richness, their leafhopper and spider assemblages were highly differentiated and comprised a number of exclusive species, some of which were endangered. Our results suggest that maximum biodiversity can best be maintained by the diversification of management types. Enhanced abundances of leafhoppers and spiders in pastures may improve prey availability for predators such as amphibians, reptiles and birds. Low-intensity grazing is currently rather uncommon in Central European fens, but our results encourage more widespread use of cattle for managing this type of habitat.

## LOW-INTENSITY GRAZING AS A TOOL FOR MAINTAINING AND RESTORING BIODIVERSITY IN TEMPERATE EUROPE

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The continuous decline in biodiversity in some European landscapes has led recently to the (re-) implementation of low-intensity grazing systems as an alternative to more cost-intensive conservation practices. This approach aims at developing habitat complexes comprising various successional stages and increasing plant species diversity on local ( $\alpha$ -diversity) and landscape scales ( $\beta$ -,  $\gamma$ -diversity). Low-intensity grazing either with domestic herbivores or semi-wild or wild herbivores enhances existing environmental gradients and generates manifold disturbance patterns on various spatial scales resulting in high habitat diversity. Livestock trampling has a so far underestimated impact on plant species composition and richness (e.g. seedbed creation). Additionally, selective herbivore behaviour facilitates the coexistence of plant species representing different functional types, including a considerable number of threatened and grazing-sensitive species. Co-occurrence of progressive and regressive successional processes on low-intensive pastures results in structurally diverse landscapes. Persistence of species-poor successional stages of dominant competitive graminoid and herb species can in many cases be inhibited by grazing. Large herbivores serve as effective vectors of diaspores, thus improving the connectivity of isolated plant populations. Low-intensity grazing represents a highly flexible concept to maintain and restore biodiversity on landscape and plant species level.



## **GRAZING AS TOOL FOR RESTORATION AND MAINTENANCE OF CALCAREOUS GRASSLANDS IN A LIMESTONE QUARRY: A FOUR-YEAR EXPERIMENT**

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In a 4-year experiment we tested effects of grazing on plant species composition and vegetation structure of calcareous grasslands in a former limestone quarry in Lengerich, northwest Germany. The area is managed by 1-month sheep grazing during summer with a herd of about 200 animals led by a shepherd. There is also a high population of free-ranging wild fallow deer that is known to graze in the project area. Both permanent and temporary fences were used to selectively exclude the animals from certain areas. We investigated ten different sites within the project area, comprising three permanent plots each: One with a permanent fence for total exclusion of all grazers, one with a smaller fence which was only installed during summer grazing period to exclude just the sheep, and one control plot without any fence. Altogether we sampled 30 permanent plots (3 m x 3 m) in 2011, 2013 and 2015. Between June and July, vegetation relevés of all vascular plant species with visual cover estimation in 5% steps were performed. Moreover, we recorded several structural parameters in 5% steps such as height and cover of trees, shrubs, herbs, grasses, bryophytes, lichen and litter, and additionally cover of stones and open soil. Results show that grazing could distinctly counteract succession processes and promote target species. Tree emergence was widely suppressed and the amount of litter was strongly reduced on grazed plots. The proportion of open soil, potentially functioning as safe site for many species, was significantly higher in grazed plots. All these effects were most significant under combined sheep and deer grazing, indicating that wild ungulate grazing alone might not be sufficient to maintain the desired open vegetation structures.

# SESSION 7 – FOREST AND WOODLAND RESTORATION AND CONVERSION

Chair: Michael Weber

Forest and woodland ecosystems are subjected to manifold human interventions (deforestation, degradation, drainage, pollution, conversion of natural forest in plantations, etc.) and natural disasters (windthrow, fire, erosion, flooding, volcanic eruptions etc.) evoking severe ecological disturbances with substantial and permanent changes in forest structures and functions.

The recovery of more natural forests with higher diversity, resilience and ecological dynamic is very often a long-term task requiring diverse interventions at different spatial and temporal scales. The session aims at exchanging knowledge and experiences about recovery approaches and the related processes under different ecological conditions.

## RESTORATION OF A SMALL CATCHMENT IN THE EIFEL NATIONAL PARK

Thomas Pütz<sup>1</sup>, Heye Bogena<sup>1</sup>, Michael Rööß<sup>2</sup>, Alexander Graf<sup>1</sup>, Wolfgang Tappe<sup>1</sup>, Roland Bol<sup>1</sup>, Andreas Lücke<sup>1</sup>, Clemens Druée<sup>3</sup>, Frank Lehmkühl<sup>4</sup>, Harry Vereecken<sup>1</sup>

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The study area, located in the southwest of the Eifel National Park, was afforested with spruce (*Picea abies*) at the beginning of the 19<sup>th</sup> century. The World War II “Siegfried Line” ran through this area, which directly influenced the water balance of the creek by a water bunker in connection to a tile drainage system. The stock of trees destroyed in the war was afforested in the late 1940s. The concept to restore the forest to its natural state was developed after constitution of the Eifel National Park in 2004. As part of the TERENO project, a 36-m observation tower, a soil sensor network, three automatic gauging stations, two weather stations, two eddy-covariance stations, various soil respiration chambers and a lysimeter station with six lysimeters were installed in the 27-ha study area from 2008 to 2010. Beside the automatic measurements, water and soil samples have been taken manually and have been analysed for various parameters, like DOC, pH, different nutrients, etc. The National Park management started the restoration to obtain a near-natural beech forest in the headwater area and along the creek by deforestation of the spruce forest. The knowledge of the interaction between the hydrological and biogeochemical processes after deforestation is still limited. The presented work would like to contribute to the understanding of deforestation effects on hydrological and biogeochemical processes in a forest ecosystem on a long-term scale.

## FOREST RESTORATION FOR INCREASED ECOLOGICAL RESILIENCE AGAINST WINDTHROWS

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Windthrow is a natural disturbance factor in forests. In Denmark, windthrow is frequent as a consequence of storms but also of a forest management characterized by even-aged monocultures. One consequence of windthrow is economic loss, but it also has significant ecological impacts, for example reduced forest climate and outbreak of bark beetle epidemics. Observations from natural forests indicate less severity of storm damages and higher resilience than in comparable nearby managed forests. This is most likely related to a more diverse forest structure with multi-layered canopies. A windthrow in the upper story will cause damage but mid-story or advanced regeneration is ready to take over and the leaf area will only be reduced very temporarily. In this study we report storm frequencies and damages based on statistics of storm events and magnitude of damages over the recent century. We also report (1) recovery after a heavy storm in three semi-natural no-intervention forests and nearby comparable forests with focus on LAI and species distribution, and (2) from an experiment with a gradient in intervention (no intervention, fence, harvesting, and slash removal) carried out on three sites all heavily damaged in 1999. Case studies and scientific literature will form the basis for the development of a conceptual understanding on the resilience capacity of different forest ecosystems and forest management. We suggest a strategy for restoring interventions for increased resilience after storms, and finally we review official policies in the light of our analyses.

## HOW TO ACCELERATE THE RECOVERY OF STREAM-NEAR VEGETATION AFTER INTENSIVE FOREST MANAGEMENT CESSATION?

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On the Baltic island Bornholm, Denmark, a buffer strip along the upper part of the stream Øle Å was left for secondary succession following a restoration clear-cut in autumn 2014. In order to investigate additional treatments that may accelerate the desired development towards a mixed riparian forest, a controlled experiment was established in parallel to the free succession. The stream-near areas were previously dominated by dark stands of non-native Norway spruce (*Picea abies*), managed intensively for timber production and with limited floral diversity. The succession rate may, however, be limited or delayed by legacy effects, such as a limited seedbank and a thick litter layer. Furthermore, a high stock of game is expected to influence the trajectory. To test different 'fast-forwarding' assisting interventions we investigated treatments including (1) fencing, (2) litter removal, (4) fencing and litter burning, and (5) fencing and litter removal with additional seeding of target tree species. The vegetation cover and composition was monitored, with special focus on the establishment of native woody species. We present results from the first two growing seasons after the intervention. The removal of litter resulted in significantly higher vegetation cover, and a difference in species composition was also seen. Woody species seems limited by the harsh growing conditions in the former spruce forest floor and by grazing.

## ADAPTIVE FOREST RESTORATION IN ROAD CONSTRUCTION AREAS: DEALING WITH SEED PREDATION AND PROMOTING FACILITATION

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The restoration of areas highly disturbed by road construction can be a challenge for ecologists and practitioners, particularly when there is the need to reconcile scientific concepts and practical solutions. We are conducting a restoration experiment sowing acorns in a degraded site located in the north-western Po plain, highly disturbed by highway infrastructure development. Among the main goals is to recreate a mixed broadleaved forest with oaks as the dominant species. To test the importance of nurse and shield effects (facilitation) in oak emergence and survival, we sowed acorns close to shrubs (*Cytisus scoparius* L.) and wood panels (small wood protective barriers). Since we started to notice acorn predation, seed removal was recorded. Rodents were identified as the main predators. Predation patterns were evaluated and compared among treatments. Topological variables that could potentially influence predation were also taken into account. Predation was quite high in general, and less abundant where shrubs were present. In the second year of the project a new device named seed shelter (patent number 201331441, University of Granada) was used to protect the seeds and thus better understand nurse and shield effects. Our results confirmed the high susceptibility to predation of acorns and provided evidence that shelter elements can influence seed predation rates and sapling performance.

## ECOLOGICAL RESTORATION ON ERODED LAND BEYOND BIOTIC AND ABIOTIC THRESHOLDS: AN EXPERIMENTAL CASE STUDY

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Restoration is a long term task aiming at restoring ecosystem structure and functions. The scale and extend of interventions are dependent on the conditions of the ecosystem to be restored, aiming at enhancing ecosystem function and direct succession. Thus, a good knowledge of the underlying processes is needed. A large-scale, long-term restoration experiment was established on severely degraded land in S-Iceland in 1999. The experiment comprised untreated controls and nine restoration treatments, representing different intensity and type of interventions. Each plot was 1 ha and treatments replicated four times. The objective was to determine the interaction between soil and vegetation development and ecosystem functions. Total vegetation cover (including vascular plants, mosses and lichens) of controls averaged around 5% over the 15-year study period, indicating the presence of strong abiotic or biotic thresholds. Conversely, total cover of all fertilized treatments increased, concomitant with formation of biological soil crust. Species richness was also the highest in fertilised treatments, including some native species important in native heath and woodland communities. During the study, the dominant forces driving the successional trajectories appeared to be the different restoration methods used. Our results show that under these severely degraded conditions, revegetation interventions are necessary to initiate natural succession and overcome abiotic and biotic thresholds.

## COLONIZATION OF WOODLAND SPECIES DURING RESTORATION – SAFE SITE OR PROPAGULE LIMITATION?

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The ecological restoration of eroded or other severely disturbed areas depends upon successful colonization of native plant species. Iceland has extensive eroded areas with limited retention of nutrients and water and unstable surfaces due to erosion and cryoturbation. These areas recover very slowly without interventions. The relative importance of revegetation and added seed sources for the colonization of key woodland species—birch and native willows—was tested in an experiment on eroded land in S-Iceland. Seedling densities were surveyed in twelve 1-ha plots representing: (1) untreated control, (2) revegetation with grasses and fertilization, (3) revegetation (as in 2) with planted seed sources, and (4) planted seed sources without revegetation. Birch and willows seedlings were first detected in 2006, six years after the initiation of revegetation and three years after the establishment of seed sources was completed. By 2015, treatments 2 and 3 had seedling densities of 0.4 and 8.8 plants m<sup>-2</sup>, respectively, while no seedlings were found in treatments 1 and 4; thus revegetation seems to generate safe sites for seedling establishment. Higher seedling density in revegetated plots with added seed sources (3) than without (2) also indicates propagule limitation. The results demonstrate that revegetation to stabilize the soil surface is a prerequisite for plant colonization of these unstable eroded areas, and that colonization can be accelerated by planting seed sources of key species.

## ERMOND-GRÓGOS: EXPERIMENTAL SETUP ESTIMATING THE EFFECT OF VOLCANIC ASH DEPOSITION ON RESTORED BIRCH WOODLAND VEGETATION, HEKLUSKÓGAR, ICELAND

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Volcanic eruptions and associated tephra (ash) fall can have detrimental impact on ecosystems, human health and society. Deforestation, agricultural intensification and other human actions that undermine ecosystem health and resilience can increase the severity of tephra hazards; e.g. damage by post-eruptive transport of tephra falling onto sparsely vegetated areas. But human intervention can also decrease the severity of a hazard event through mitigation actions, including environmental management that improves ecosystem health and reduces disaster risk by increasing resilience to tephra-fall. A large-scale restoration project in Iceland, Hekluslógar, aims at restoring native birch woodlands in order to prevent post-eruptive transport by wind of volcanic ash from Mt. Hekla. We report on a field experiment in the Hekluslógar area, assessing the impact of tephra deposition on 8-year old birch (*Betula pubescens*) plantation. Sixteen experimental plots with about 20 plants each were established within the plantation; forming a randomized block design with treatments of 4, 8 or 16 cm of tephra derived from a local source and controls without tephra. We fertilized half of the plants within each plot to evaluate the effects of fertilization as a potential post-eruptive response action to stimulate recovery of young birch plants and other vegetation. Birch survival and vigour after one growing season were significantly lower in plots with 16 cm of tephra than other treatments, but there was no effect of fertilization. The effects of tephra on the planted birch and vegetation composition will be discussed in relation to ecosystem approaches for disaster risk reduction.

## DISRUPTION OF LANDSCAPE FIRE TRAPS IN MEDITERRANEAN BASIN ECOSYSTEMS BY THE COMBINATION OF SHRUB CLEARING AND PLANTATIONS

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Land abandonment and climate change have led to an increase in burned area in the last decades in the Mediterranean Basin and, subsequently, have promoted shifts from mature tree forests to fire-prone shrublands. Regeneration of fire-prone species is also favoured by disturbances, and places ecosystems in a feedback loop of fire occurrence and degradation (landscape trap). Considerable efforts are needed to revert degradation processes, and the reintroduction of native woody species to accelerate succession towards a desired late-successional stage is a fundamental step. Here, we evaluate a restoration action in SE Spain, aiming to disrupt “landscape traps”. The action was performed in 2003 in shrublands resultant from a previous fire in 1979. The experiment combines plantations (Plantation/No plantation) of three late-successional species with a clearing of flammable shrubs (Clearing/No clearing). Treatments covered 1,000 m<sup>2</sup> and were replicated three times. Species cover and biomass were assessed three and 13 years after the treatments. We observed that the combination of planting and clearing moved the community towards a mixed shrubland of resprouter and seeders with lower amount of total and flammable biomass. In contrast, plantations without the elimination of fire-prone species resulted in an unsuccessful treatment. Seeder species competed with planted individuals and precluded establishment and growth. Additionally, ecosystems were more fire-prone by the greatest loads of total and dead fine biomass. These results are of noticeable interest because there is scarce information about restoration actions at mid-and long-term, and give insights for designing suitable restoration actions.

## REFORESTATION TRIALS ON DEGRADED TROPICAL PEATLANDS

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Tropical peat swamp forests (PSF) of Southeast Asia are a great carbon store and a major hotspot of biodiversity. During the last decades these lowland ecosystems have been converted to plantations and agriculture at a breath-taking pace and repeated fires have accelerated their degradation. Our work searches for practical techniques for vegetation restoration on the degraded PSF. We established seedling trials with local PSF species on a clear-felled, drained and several times burnt deep peat area in the Ex-Mega Rice area in Central Kalimantan, Indonesia. We tested selected silvicultural techniques (fertilizing, mounding and weeding) for five species known to have potential for reforestation. Seedlings grown in a field nursery were planted in three replicate blocks within 2 km distance in 9 m x 9 m plots (altogether ca. 2500 seedlings in 92 plots). In one block, each plot contained one species, treatment or combination of treatments with 12–36 seedlings per plot. Growth and mortality of the seedlings and environmental variables (water table, temperature, light) were monitored for two years. Effects of environmental variables and treatments on the growth rates were tested with mixed-effect models, and effects on the mortality were tested with Cox regression. The water table position was the most influential environmental variable affecting growth and mortality but the sensitivity of the species varied substantially. Of the treatments, fertilizing had clearest positive effect both on growth and survival, whereas the results from mounding and weeding were less clear. With the results we were able to formulate recommendations for species-specific use in restoration, and increase the ecological knowledge on these little studied PSF species.

## ASSESSING FLOOD TOLERANT LEVEL OF SIX URBAN TREE SPECIES FOR URBAN FOREST ECOSYSTEM RESTORATION IN LOUISIANA, USA

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The climate records in the Gulf Coast of Mexico region of the USA documented an increased precipitation, extreme climatic events, and flooding. Recent flooding events in New Orleans, Louisiana induced by hurricanes Katrina and Rita demonstrated the urgent need for research addressing urban flooding and how urban trees cope with the stress. Understanding the flood tolerant level of urban trees is crucial for species selection in post hurricane urban forest ecosystem restoration. The objective of this study was to rank urban tree species by flood tolerant level through assessing their physiological responses to periodic flooding. Saplings of sweetbay magnolia (*Magnolia virginiana*), red maple (*Acer rubrum*), nutall oak (*Quercus nuttallii*), live oak (*Q. virginiana*), sawtooth oak (*Q. acutissima*), and shumard oak (*Q. shumardii*) were subjected to periodic flooding treatments consisting of a two-week flooding period (flooding cycle) followed by a three-week dry-down period (recovery cycle). Data on photosynthesis (Ps), stomatal conductance (Sc), and transpiration (Tr) were collected both for the flooding cycles and for the recovery cycles using a Licor-6400 Portable Photosynthesis System. Independent t-tests, paired t-tests, and two-way ANOVAs were used to analyse data with R software. The study found that the flood tolerant level of six species is different, which may influence the sapling survival and species selection in urban forest ecosystem restoration in flood-prone areas.

## HABITAT QUALITY ASSESSMENT OF HERB-RICH SPRUCE FORESTS

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The Natura2000 network contains many different habitats in Estonia, including old-growth forests and semi-natural woodlands. Vegetation composition as well as the structural and functional qualities of a forest habitat type – Fennoscandian herb-rich forests with *Picea abies* (EU Habitats Directive habitat type 9050) – are analysed in this study. The study is based on sample plots measured in 2014 and located in protected and non-protected areas. *Aegopodium*, *Filipendula* and *Oxalis* vegetation types are included for assessment of vegetation, tree structure and deadwood composition. Habitat composition and dynamics on conservation sites are compared with commercial forests and possible ecosystem restoration measures are discussed in the study. 46% of the studied habitats have considerably lowered their initial conservation value and 49% have developed towards habitat type 9010 during 2004–2014. The implementation of the Natura2000 network as set of natural habitats in which management is not allowed leads to inefficient conservation policy and destruction of semi-natural forest habitats. Habitat type 9050 is mostly human-influenced semi-natural forest in Estonia that requires grazing and other management activities for maintaining the habitat in a good condition. Such frequent management activities should be acknowledged and supported in the Natura2000 network. Appropriate restoration measures should be applied on the sites where protected habitats have already significantly lost their habitat value.

# SESSION 8 – RESTORING MULTIFUNCTIONAL ECOSYSTEMS AND LANDSCAPES

**Chairs: Thomas Knoke, Anja Rammig**

There are many approaches to the management of multifunctional ecosystems and landscapes, while restoration is often underrepresented. Addressing multiple functions through restoration poses various challenges, which include: How to quantify and model the actual functions and how to develop “optimal” target values? What are the preferences of people regarding ecosystem functions at various spatial scales? Is optimization of multifunctional ecosystems or landscapes feasible and/or meaningful? What can restoration do to minimize trade-offs between various functions? Are multiple functions better addressed by segregation or integration concepts? We present inter alia, socio-economic surveys, feasibility studies, empirical comparative or theoretical approaches, scenarios analyses, adaptive management investigations as well as all kinds of modelling approaches directed to restoration.

## PLANNING FOREST LANDSCAPE RESTORATION IN CENTRAL CHILE BASED ON RECENT HISTORICAL FOREST PATTERN AND MULTIPLE FUNCTIONS

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Multifunctional landscape restoration approaches are urgently needed, considering the amount of conversions from natural ecosystems towards intensive land uses. While restoration ecology has traditionally focused on ecosystem and biodiversity recovery according to historical reference states, the emerging Forest Landscape Restoration (FLR) approach aims to restore primary forest functions on a landscape scale to regain ecological integrity for supporting human well-being. Two fundamental tasks for FLR are the identification of a) areas requiring restoration and b) restoration areas enhancing multiple functions. As integrative planning approaches are lacking so far, we developed a method for identifying forest restoration areas accounting for historical forest patterns, while simultaneously targeting multiple forest functions. We used habitat suitability models based on recent historical forest occurrences and regeneration patterns to predict suitable forest restoration and regeneration areas. We mapped potential forest functions over the whole landscape and assessed “multifunctional hotspots” using spatial multi-criteria analysis (SMCA). Finally, predicted restoration and regeneration areas were combined with a map of multifunctional synergies, to designate multifunctional restoration areas. We tested this for the dry forest landscape of Central Chile – an international biodiversity hotspot that has undergone considerable deforestation in recent decades. With our modelling approach we show that identifying multifunctional hotspots is feasible, and it can be used for spatial optimization of restoration targets. Using SMCA for exploring scenarios of different preferences can be useful for developing optimal target values.



## IMPROVING MULTI-OBJECTIVE ECOLOGICAL FLOW MANAGEMENT WITH FLEXIBLE PRIORITIES AND TURN-TAKING: A CASE STUDY FROM CALIFORNIA

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The Sacramento River Bay Delta system in California is highly regulated to meet the water needs of agriculture, human communities and a range of natural resources. Hydro-project and water conveyance operational plans are currently informed by simulation modelling that attempts to globally optimize water allocation over a vast array of location specific objectives. We demonstrate an improved method for multiple objective allocation of water: “turn taking” optimization (TTO) within a coupled multi-model cloud computing framework. We apply TTO to an array of physical hydrologic models linked with the Ecological Flows Tool (EFT), a multi-species decision support framework for evaluating habitat conditions for 13 representative species and 31 indicators. TTO incorporates the existing water delivery and socio-economic water management criteria, priorities and constraints, and optimizes monthly water release patterns each water year using a dynamically shifting set of priorities. As an individual EFT indicator is successful in a particular year, its priority weight in one or more subsequent years is reduced (depending on the life-history needs of each species). Rather than attempting to meet criteria every year, this “turn taking” creates additional flexibility and opportunities for other indicators to be successful in other years. Comparing the overall number of EFT indicators that were successful over simulation years using TTO to a business-as-usual reference case (that did not use TTO) revealed that 12 EFT indicators were able to realize an improvement with TTO, 14 showed no change and five showed a reduction with TTO. TTO provides an innovative new technique to assist water managers balance competing objectives.

## ENHANCING THE RESILIENCE OF WATER RESOURCES THROUGH LAND RESTORATION IN RANGÁRVELLIR, ICELAND – AN OVERVIEW OF THE HYDRORESILIENCE PROJECT

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Resilience is the capacity of an ecosystem to respond to a perturbation or disturbance by resisting perturbations and recovering quickly. In this presentation we will present the HydroResilience project, which will assess the effects of ecosystem restoration on the resilience of water resources by increasing the field capacity (FC) in the Rangárvellir restoration area in southern Iceland. An increased FC secures water availability during droughts, reduces the flood risk during heavy precipitation events and enhances the water quality in some cases. The Rangárvellir area presents ideal conditions for such investigations. Dramatic deforestation during the last millennium and year-round livestock grazing along with devastating ash emissions during volcanic eruptions and a harsh sub-polar oceanic climate have led to severe degradation in Rangárvellir. Since the beginning of the 20<sup>th</sup> century diverse restoration measures have been implemented making Rangárvellir an ideal case study to investigate the effects of restoration on the resilience of water resources. In this project we will assess and quantify the evolution of water resources in Rangárvellir by assessing the runoff dynamics in the main rivers of Rangárvellir under four main scenarios: (1) present conditions, (2) degraded conditions as was the case 100 years ago, (3) under hypothetical fully restored ecosystems and (4) under conditions of a scenario developed in collaboration with local stakeholder groups to optimize socio-ecological benefits. For this purpose, the dynamics of the relevant hydrological processes in the area (incl. river runoff, ground water table, snow cover duration, soil moisture dynamics) will be reconstructed using hydrological models to run the above mentioned scenarios. The scientific findings and conclusion of this project will generate valuable insights on the effects of land restoration on water runoff and water quality. The presentations will outline the main methods used during the project and conclude by providing an outlook on the expected results.

## HYDROLOGICAL RESILIENCE AND CARBON STOCKS IN WET BROADLEAVED FORESTS IN NORTH-WESTERN GERMANY

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Forests are important sinks in global carbon sequestration. However, it is still unclear how the expected effects of climate change, such as extended periods of drought, longer vegetation periods and elevated CO<sub>2</sub>-levels, might influence essential ecosystem services like carbon storage in temperate broadleaved forests. Pre-disturbed wet forests with extensive drainage systems still existing are especially vulnerable to future hydrological changes. Therefore, within the project “Fit for climate change” ([www.fit-fuer-den-klimawandel.de](http://www.fit-fuer-den-klimawandel.de)), we are currently testing and implementing rewetting measures in wet oak-hornbeam forests of north-western Germany aiming at the restoration of hydrological conditions of formerly drained soils to mitigate increasing drought stress. By cascade-like blocking of minor drainage ditches with loam-dams in eight study sites, we intend to keep backwater in the sites for a longer time during summer months, while extreme flooding in winter can be avoided by outflow through major ditches. In the course of an intense and extensive accompanying research concept, we analyse the amount of organic carbon currently stored in living biomass, coarse woody debris and soils in 14 study sites, each containing four study plots à 0.1 ha. While the basic assessment, prior to the implementation of rewetting measures, was completed in years 2014–2015, first monitoring surveys are planned for 2017. Additionally, a close and regular monitoring of the water levels is conducted every two weeks. So far, results highlight the value of wet forests as carbon sink and emphasize the need to restore the historical hydrological regime, in order to improve the ecosystem’s resilience to a changing climate.

## RESTORATION OF DEGRADED ARID- AND SEMI-ARID SAVANNAS IN SOUTH AFRICA

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Savanna rangeland systems are used for livestock and/or game farming. Degradation of these systems leads to an increase in the density of the woody component (shrubs & trees), also called “bush encroachment” (BE), which causes an imbalance in the woody:grass ratio due to a competition of moisture and nutrients. In restoration practices, various arboricides are used to selectively (hand) and non-selectively (airplane) control BE. The grazing capacity was significantly reduced from 94.5 ha/LSU in unrestored BE areas to 10.5 ha/LSU in controlled areas in the semi-arid savannas of the Molopo, South Africa. Aboveground phytomass production increased significantly from 381 kg/ha to 1797 kg/ha (airplane-control) and 1440 kg/ha (hand-control), whereas grass tuft density also increased significantly from 4 tufts/m<sup>2</sup> to 12 tufts/m<sup>2</sup> after control. The point-to-tuft distance, which describes the degree of erosion, was significantly decreased from 19.2 cm in BE to 9.6 cm in controlled areas. There is a linear increase ( $r^2 = 0.85$ ;  $P < 0.001$ ) in fodder production (kg/ha) with a decrease in woody phytomass (TE/ha). Climax grass species, e.g. *Schmidtia pappophoroides*, significantly increased in controlled areas compared to unrestored BE areas, where pioneer grasses such as *S. kalahariensis* dominated. Chemical control, however, requires higher financial inputs. The application of good grazing practices, including rotational grazing, still remains the best management strategy, as it ensures a dense stand of perennial, palatable grasses with high phytomass and less BE. The landscape functionality, which can be measured as an index of stability, nutrient cycling and infiltration rate was not significantly different in BE and controlled areas (difference of 0.5–0.7%).

## EXPLORING THE POTENTIAL ROLE OF PRIORITY EFFECTS FOR ECOLOGICAL RESTORATION

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The role of history in community assembly is uncontested, since plant communities develop over time from early to later successional stages. Species that arrive first can significantly affect further assembly and hence also ecosystem functioning and species composition. Often in restoration we plant or sow desired species and hope that they will manage to out-compete undesired, often invasive, species. In this talk we will explore the concept of priority effects in assembly and its potential to be successfully used in restoration. We will set these aspects within a global context of theory and practice and link it to implications of current UN restoration policy (Bonn Challenge). Since the term *priority effect* is used in different ways by different researchers, our work includes defining the term as well as analysing its potential for more habitats than grasslands. We work with extensively managed European grasslands, which are some of the most diverse habitats on a small scale, but are severely threatened by both agricultural intensification and land abandonment. In our case studies, priority effects can be used to create more productive yet still diverse grasslands that motivate farmers and conservationists. This is quite different to many restoration challenges in other parts of the world, where the main goal is re-establish a specific set of species and avoid establishment of invasive species. A series of different experiments (controlled and field) testing priority effects in grasslands under different conditions will be presented, including testing differential effects of legumes arriving before or after other plant functional groups, and effects of initial weather conditions will be explored. We found that outcomes were affected by weather conditions during experiment initiation, as well as by effects of soil seed bank, and by whether experiments were conducted under field or controlled conditions. The complementary talk of Weidlich et al. focuses on the role of plant traits in a large field experiment (Priority Effect Experiment Jülich) testing priority effects.

## RESTORATION OF TOTORA REED BEDS (*SCHOENOPLECTUS CALIFORNICUS*) IN HUANCHACO, PERU: LINKING FISHERMEN AND TOURISM

Julie Marcus, Mickey Marcus

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This presentation describes a proposal to work with a group of fishermen to build and restore man-made wetlands of local importance for the manufacture of boats made from the Totorá Reed (*Schoenoplectus californicus*). The fishermen use the reeds to build boats, and the local beach community of Huanchaco, Peru has capitalized on these iconic boats as a symbol of the town, and as a draw to their tourism industry. Present day fishermen in Huanchaco continue to build traditional reed boats which are used for inshore net fishing (within 3–5 km of the coast), and increasingly to provide tourists with a boat ride through the surf. The extensive coastal wetlands have been significantly reduced in size due to coastal erosion, and the loss of the reed beds has required the fishermen to build small individual wetlands by hand-digging into the groundwater and planting rhizomes of *S. californicus*. Although there is a loose collective of approximately 20–30 active fishermen, they are each possessive of their individual reed beds, cultivation techniques, harvesting frequency, and drying procedures. Each wetland also requires the erection of wind protection. The coastal erosion has forced the abandonment of many reed beds and the creation of new wetlands further inland where the depth to the water table requires deeper excavation. The hand-dug wetlands have thus become smaller, and the success of the wetlands less predictable due to water salinity and fluctuating water levels. We describe and propose a conceptual design to construct multiple small wetlands for use by individual fisherman and the use of a series of groundwater monitoring wells to evaluate the regional hydrology.

## QUANTIFICATION AND VALUATION OF ECOSYSTEM SERVICES TO OPTIMIZE SUSTAINABLE RE-USE FOR LOW-PRODUCTIVE DRAINED PEATLANDS

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Almost one-third of European peatland resources is situated in Finland, where more than half of the original peatlands have been drained to increase tree growth. However, 20% of the drained peatland area does not produce enough timber to fulfil commercial purposes. At the same time, their biodiversity is degraded, they may continue environmental loading to watercourses and act as greenhouse gas (GHG) sources. A key question concerning the use of peatlands is what to do with these low-productive drained peatlands that have been left aside from active forestry. There are needs to use the low-productive peatlands in the production of bioenergy, timber and peat. Simultaneously, there are needs to restore the most valuable drained peatland habitats, which might recover towards their original state. The problem is that the impacts of the different options on biodiversity, environment and economy are not yet fully understood and thus it is hard to give proposals for re-use actions for specific areas. The challenge is to develop mechanisms that can balance the conflicting demands on the use of the drained peatlands and ensure their sustainable use. Our 5-year EU funded LIFE+ project LIFEPEATLANDUSE (2013–2018) consolidates and increases the knowledge on the impacts of peatland re-use on ecosystem services. The aim is to find cost-efficient re-use options to low-productive drained peatlands, which help to prevent or stop decline of biodiversity and environmental loading to watercourses, and improve capacity of peatlands to store greenhouse gases. There are seven different peatland re-use options under investigation, representing the economic activity as well as measures related to the protection. The purpose is to evaluate and predict their potential impacts on the peatland landscapes, if they were applied in practice.

## RESTORING HYDROLOGIC PROCESSES IN FLOODABLE CATTLE RANCHES IN PARAGUAY BY TAILORING REVEGETATION ACTIONS

Verónica Cruz-Alonso<sup>1,2,3</sup>, Karim Musálem<sup>2,4</sup>, Fernando Viñeola<sup>5</sup>, Jorge Mongil-Manso<sup>3</sup>, Amado Insfrán<sup>4,6</sup>, José María Rey Benayas<sup>1,4</sup>

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Deforestation of Paraguayan native forest due to cropland and pasture expansion is the main driver of land use change in the floodable lowlands of the Humid Chaco Ecoregion. In this context, forest patches increase ecosystem heterogeneity and provide services for economic activities. We assessed the relationships between surface water hydrology and vegetation cover in a sustainable cattle ranch – a reference agroecosystem – where periodical flooding limits livestock farming. Evaporation and infiltration were evaluated under native vegetation types (forest, grassland, and forest-grassland ecotone) and at different distances from single native trees (at the tree trunk, canopy edge, and open areas). Infiltration and evaporation rates were related to vegetation types. While final infiltration rates were greater in forest (94.5 mm h<sup>-1</sup>) compared to grassland (22.0 mm h<sup>-1</sup>) and forest-grassland ecotone (11.5 mm h<sup>-1</sup>), evaporation was significantly lower in forest (0.015 mm h<sup>-1</sup>) than in the two other vegetation types (grassland: 0.17 mm h<sup>-1</sup>; ecotone: 0.109 mm h<sup>-1</sup>). Initial infiltration rates at the tree trunk were marginally greater compared to open areas (785.0 mm h<sup>-1</sup> vs. 77.5 mm h<sup>-1</sup>). Overall, our results suggest that the introduction of forest islets, or even scattered trees, in deforested pastures could enhance hydrological services, reduce flood duration and, as a consequence, facilitate cattle raising while promoting local biodiversity linked to native forest patches and trees.

## RESILIENT AND MULTIFUNCTIONAL MEDITERRANEAN-TYPE ECOSYSTEMS: IMPROVING RESTORATION BY TRAIT-BASED SIMULATION MODELLING

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Ecosystem services provided by Mediterranean-type ecosystems (MTEs) are currently at risk due to global change (e.g. change in land use, nitrogen deposition, climate). Ecological restoration increasingly aims at restoring towards resilient and multifunctional landscapes. Therefore, we require a fundamental understanding of the link between ecosystem composition, related ecosystem functions and services, and influencing environmental drivers. Measurable plant traits (e.g. height, specific leaf area, seed mass) have been recognised as such a link. However, this knowledge has not yet been included into restoration research of MTEs. In our study, we aim at closing this gap. We will present a conceptual framework for a trait-based simulation model that links ecosystem composition given by its traits, ecosystem functions, and the provisioning of ecosystem services of MTEs. The model is intended to assist an ongoing large-scale restoration project in Western Australia (the Ridgefield experiment) on multiple ecosystem services. In a full factorial design, trade-offs between services will be assessed, and the resilience of the ecosystem towards multiple drivers of global change will be tested.

## PRIORITIZING PROTECTION MEASURES THROUGH ECOSYSTEM SERVICES

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The Napahai Wetland is a typical plateau wetland in the Hengduan Mountain Area, China, with characteristic geography and abundant biodiversity. Nowadays, serious ecosystem degradation in the Napahai Wetland has occurred from natural and human factors, therefore, urgent protection measures must be taken to protect this important wetland. Understanding the value of ecosystem services is critical to wetland protection measures making. Accordingly, we assessed the value of ecosystem services in the Napahai Wetland using the Market Analysis Method that elicit the value of ecosystem services according to its price in the actual market, and the Revealed Preference Method that use a relation with a market good or service to estimate the value for the ecosystem services. Additionally, our study encompassed analysis of the value composition of each ecosystem services, including product supply, climate regulation, water supply, flood control, environmental purification, nutrient conservation, habitat, tourism, and scientific research. The results indicated a total monetary value, for all ecosystem services in the Napahai Wetland, of 237.96 million Yuan (2008: comparable price), which translates into a unit area estimate of 76 thousand Yuan/ha. The value associated with tourism accounted for 43.7% of the total, and the values associated with habitat, nutrient conservation, scientific research, and flood control accounted for 13.5, 9.7, 8.1 and 7.2%, respectively. Product supply only accounted for 9.7%. These findings suggested that, the Napahai Wetland provides abundant sociocultural resources to humans and significantly contributes to life support systems. In comparison, product supply was not shown to be a major component of ecosystem services. On the basis of this analysis of ecosystem services, we have proposed some actions that can be taken to protect the Napahai Wetland.

## SOIL CARBON SEQUESTRATION AND BIODIVERSITY RECONSTRUCTION IN REHABILITATED COAL MINE SPOIL IN A TROPICAL REGION, INDIA: A CASE STUDY

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The study presented was conducted on a degraded coal mining habitat in a dry tropical region of India where mining is one of the serious problems. Degraded soils have poor ability for further vegetation development. Moreover, recovery by natural succession is very slow process. Therefore, biological soil restoration by establishing desirable plant species is more reliable than other rehabilitation procedures. We selected four woody species which were indigenous and hard in nature; of which two of them (*Albizia lebbbeck* and *Albizia procera*) were leguminous tree and short stature in size, while remaining (*Tectona grandis* and *Dendrocalamus strictus*) species were non-leguminous in nature. The objective of the study was to quantify biodiversity recruitment under plantation plots, and to estimate soil carbon accumulation and their impacts in redeveloping soils of planted species followed by time. Results indicated that influence of plantations on soil redevelopment and accumulation of soil organic C was more pronounced. Recruitment of plant biodiversity among planted plots was varied significantly due to effects of species and time. Redevelopment of soil was strongly linked to biodiversity development and carbon sequestration in planted plots, which strongly supports that vegetation development is a main attribute that can bring more stability and functions in a redeveloping degraded ecosystem.

# SESSION 9 – MONITORING RESTORATION

**Chair: Johannes Kollmann**

Calls for “adaptive” restoration of ecosystems have become more frequent in response to rapid environmental change. Regular returns to a project site to check success of restoration measures, and adjust them if necessary, are essential but too often not routinely performed – due to lack of money, time, or appropriate methods. This session presents a variety of means by which restoration success can be efficiently assessed in plant populations and communities of terrestrial ecosystems.

SESSION 9-01 – MONITORING RESTORATION

## CAN EARLY MONITORING INFORM ABOUT THE SUCCESS OF PEATLAND RESTORATION?

Katharina Strobl, Johannes Kollmann

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Nature conservation has increasingly focused on the rewetting of drained peatlands, since they provide essential ecosystem services, in particular carbon storage, habitat provision and drinking water supply. Restoration or regeneration are nowadays commonly applied to many European peatlands. As the rewetting of degraded peatlands is complex and their regeneration slow, more knowledge is needed about the typical developments after restoration measures. This would inform practitioners about the need to implement corrective measures at early stages. Therefore, the aim of this study is to evaluate the success of formerly drained peatlands used for forest plantation, following 18 years of rewetting. Various ecosystem characteristics were monitored in 12 sites in ‘Fichtelgebirge’, northern Bavaria. The homogeneity of the site conditions as well as the applied measures allowed for the use of a space-for-time substitution design. Preliminary results indicated an increasing site quality after 3–5 years, based on peat characteristics, light and water availability, vegetation structure, and the cover as well as the numbers of typical plant and animal species. However, after 10 years, the quality of the restored peatlands in respect of the above-mentioned attributes declined again. These observations point out the risk of false conclusions on restoration success when based on short-term monitoring, and emphasise the need for long-term observations in these slowly regenerating ecosystems.

## SOME ISSUES OF STATISTICAL UNCERTAINTIES IN ASSESSING OUTCOMES OF RESTORATION

Tomasz Wyszomirski<sup>1</sup>, Klara Goldstein<sup>1</sup>, Łukasz Kozub<sup>1</sup>, Agata Klimkowska<sup>1,2</sup>, Wiktor Kotowski<sup>1</sup>

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Assessment of restoration efforts requires comparison of restored sites with references. Their equality would be a proof of restoration success. In statistical terms, this equality constitutes the null (nil) hypothesis. Null hypothesis can never be proved, as even very high p-values obtained from statistical tests do not support it. Only by employing some kind of uncertainty intervals one can get insight into possible magnitude of differences between sampled communities. If narrow, confidence intervals may sometimes provide evidence that compared communities are indeed very similar. Conversely, wide intervals show that even huge differences cannot be excluded. We present an uncertainty-oriented approach as applied primarily to comparisons aimed at the assessment of restoration success in communities of interest. We use data gathered within the Miracle (Mires and Climate) Project, derived from a few restoration experiments in Western Europe. Analyses of vegetation data include eco-hydrological habitat factors and plant functional traits approach. We employ various techniques, including randomization and bootstrap methods to illustrate pitfalls of statistical significance testing. Considering also examples from the literature, we arrive at the view that the problem of non-detection of potentially important differences (i.e. committing type II error in statistical testing) may lead to seriously flawed conclusions about restoration success. Changing approaches from testing-oriented to more quantitative and uncertainty-oriented may help to overcome the problem.

## RESTORING ECOSYSTEMS: PREDICTING THE FUTURE WITH HELP FROM SUCCESSIONAL RATES

Knut Rydgren<sup>1</sup>, Inger Auestad<sup>1</sup>, Rune Halvorsen<sup>2</sup>, Liv Norunn Hamre<sup>1</sup>, Jan Sulavik<sup>1</sup>

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In barren landscapes where recovery may take decades, methods for calculating the direction and rate of vegetation change, i.e. successional rates, are invaluable for evaluating ongoing restoration processes. Successional rates may be calculated by means of ordination if one of the axes strongly reflects a successional gradient, and we have species compositional data recorded at two or more time-points. However, ordination has been little used to calculate successional rates in restoration studies, and additional studies are necessary to assess the usefulness of these techniques for estimation of successional rates. We used species composition data from five alpine spoil heaps in W Norway recorded at three time points (early 1990s, 2008 and 2015) to calculate successional rates, using different ordination techniques (DCA and GNMDS). Based on the results we tested previous hypotheses of time to recovery for the spoil heaps (data from two time points only), and examined the reliability of the successional rates estimates. Previous estimates of vegetation recovery in 50 years proved too optimistic, as successional rates decreased non-linearly with time. Although the different ordination techniques predicted somewhat different rates, these techniques may be useful for making successful prediction of restoration, and of particular value when restoration proceeds slowly.



## IS THE OBSERVER EFFECT SIGNIFICANT IN VEGETATION ASSESSMENT OF RESTORED METALLICOLOUS GRASSLAND?

Sylvain Boisson, Grégory Mahy

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Projects that aim at habitat restoration require protocols of vegetation assessment to monitor the evolution of the restored ecosystems over time. In most cases, multiple assessors are needed and some studies have shown that the variability among observers can be significant. In the context of tropical grassland, few studies quantified the impact of the observer on the results, reducing the capacity to replicate conclusions, and, therefore, to plan restoration strategies at large scale. This study aims to quantify the variation among observers using two phytosociological methods on restored metalicolous grassland, and to test whether variation in the assessment could impair the conclusions of the vegetation assessment. Four observers were selected to perform monitoring of quadrats in two distinct habitats identified in four restored ecosystems. All observers sampled seven metrics based on phytosociological methods and two of them also performed a complete vegetation sampling of the quadrat, including species identification and cover in quadrat. For metrics based on cover, variation of measure existed among the observers. For metrics based on counting, no variation was highlighted and the observers were able to distinguish and identify species. These results emphasize that a same method could lead to distinct results according to observer and, in restoration projects, it is crucial to ensure a correct transfer of protocols of vegetation assessment in order to reproduce equally the method.

## MULTI-LEVEL MONITORING AFTER THE RESTORATION OF A NETWORK OF FOREST PONDS AND VERNAL POOLS

Francis Isselin-Nondedeu<sup>1</sup>, Pauline Hervé<sup>1</sup>, Renaud Jaunatre<sup>2</sup>, Boris Vary<sup>1</sup>, Elodie Pineau<sup>1</sup>

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Forest ponds with permanent and temporary waters are ecosystems of great interest in terms of biodiversity and biogeochemical functioning. They are generally characterized by oligotrophic water with low pH. Also, they support populations of amphibian species and invertebrates like dragonflies (Odonata). However, in many forests of Europe, these types of wetlands were degraded by forestry. In 2012, we restored 32 forest ponds including vernal pools that had been intensively degraded by forest industry in the North-West of France (Chinon, Indre-et-Loire). Most of the ponds were filled, drained and planted with trees. After digging and cutting trees, we monitored three major taxonomic groups, vegetation, amphibians, and Odonata from 2012 to 2016, both in reference ponds (non-degraded, and undisturbed) and restored ponds. In addition, we measured several hydro-geochemical variables. To take into account the multiple dimensions of ecological restoration objectives in our site, we used a new synthetic framework to assess the success of the whole project. We present the main results for the ecological variables, the outputs of this framework, and discuss its usefulness.

## PLANT POPULATION VIABILITY ANALYSIS OF A FLOODPLAIN SPECIALIST – IMPLICATIONS FOR RESTORATION OF ALPINE RIVERS?

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Early-successional plant communities of alpine floodplains are threatened by river regulation. In the case of *Chondrilla chondrilloides*, a once wide-spread specialist of dynamic gravel bars, there is only one population left in Germany that urgently needs conservation and restoration. Successful management of small and isolated populations of endangered species depends on an understanding of the factors controlling population viability. Thus, we mapped all individuals of *Ch. chondrilloides* in the population and identified the factors contributing to dispersal or habitat limitations. With more than 1000 individuals, the population was above a level from which we would expect damaging impacts of inbreeding or demographic stochasticity. Distribution and microsite requirements were not so specific that habitat limitation seems likely. Furthermore, seed mass, germination rate and seedling survival indicated no fitness reduction. We conclude that the remaining population of *Ch. chondrilloides* is vulnerable but not trapped in an extinction vortex. Management of the species should focus on establishment of new populations in restored floodplains to ensure long-term survival of the species.

## A POPULATION APPROACH TO EVALUATE GRASSLANDS RESTORATION – A SYSTEMATIC REVIEW

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How do we know if restoration goals are achieved? – In practice, the criteria used to evaluate the success of restoration actions are numerous and can be defined at different ecological scales, i.e. at the population, community or ecosystem level. Most studies about restoration success monitoring assessed attributes corresponding to the community or ecosystem level, like species diversity, vegetation structure and ecological processes. Has the population approach been disregarded in evaluation of restoration success? This systematic review of the literature aimed to identify how often plant population traits were used to monitor restoration of grasslands. Practically, 3133 papers were reviewed among which 35% reported monitoring of plant species after a restoration action. Only 150 papers used a population approach and represent the core of this review. Detailed results and paper content will be presented with the aim to identify restoration protocols (with or without species addition), species of interest, population attributes and processes considered to evaluate restoration success.

## BOTANICAL INDICATORS FOR MONITORING PROGRESS AND SUCCESS OF LOWLAND CALCAREOUS GRASSLAND RESTORATION ON EX-ARABLE LAND

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Calcareous grassland in Europe has markedly declined in recent centuries, and remnants are threatened by degradation and species loss. Thus, there is an urgent need to reverse the decline via habitat creation and restoration. However, due to dispersal limitation and microsite limitation, natural regeneration may take centuries. Active species introduction can speed up the process, but only up to a point. Thus, over short to medium timescales, we cannot expect re-created calcareous grassland to become indistinguishable from high-quality local remnants, and for reasons of historic contingency, such a goal may not even be appropriate. Thus, the requirement for restoration goals to be realistic and attainable necessitates special consideration. Accordingly, policy documents usually tend to define criteria for restoration success in fairly broad terms, e.g. by prescribing the restoration of 'calcareous grassland of wildlife value'. Here, we develop realistic criteria for assessing restoration success, based on re-analysis of previously collected chrono-sequence data, and investigate how an evaluation based on paired local reference sites differs from one based on a wider pool of reference sites spread over a larger geographic scale, which may better reflect a notion of 'calcareous grassland of wildlife value'. We develop criteria for deciding when lowland calcareous grassland has been successfully restored, and species indicators for measuring restoration progress.

## TESTING A PHYTOMETER APPROACH FOR ASSESSING RESTORATION SUCCESS IN MONTANE PEATLANDS

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Restoration of degraded peatlands has become common practice in many temperate regions, while the limiting factors for re-establishment of the respective plant communities are not fully understood. Near-surface water tables are believed to be a precondition for peatland vegetation, whereas other factors, like the importance of light or limitations of plant dispersal, are discussed controversially. The current study evaluates restoration of plant communities in eight formerly degraded montane peatlands in northern Bavaria testing a phytometer approach. It focuses on three target species (*Drosera rotundifolia*, *Eriophorum vaginatum*, *Vaccinium oxycoccos*), combining a field survey of the study species with phytometer experiments in the field and in a greenhouse. The results show that habitat conditions did not generally improve with increasing time since restoration. Correlations of phytometer performance with abiotic variables in the field, and manipulated water tables in the greenhouse, underlined the significance of soil water conditions, while light availability was found to be of minor influence. The comparison of phytometer performance with natural populations of the species indicated both site and dispersal limitation. Overall, the phytometer approach contributes to an improved understanding of post-restoration development in degraded peatlands. It helps with decisions concerning active plant re-introduction, while it may be too expensive and too time-consuming for standard monitoring of degraded peatlands.

## MARINE ECO-DAMAGE ASSESSMENT METHODS BASED ON THE ECO-RESTORATION COST IN CHINA

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The marine eco-damage situation is very serious in China due to project construction, oil spillage, dumping, discharge of pollutants, enclosing and reclamation of sea areas, overfishing, destruction of coral reefs and mangroves, habitat destruction, etc. Also, the marine eco-damage assessment in China is currently without a set of scientific, systemic, reasonable and unified evaluation methods and standards. The ecological cost of this series of activities has neither been effectively evaluated, nor did stakeholders get reasonable compensation, which led to irreparable damage of fishery, aquaculture and marine ecosystems. The paper puts forward a set of suitable methods to assess marine eco-damage under China's national conditions according to the eco-restoration theory through the analysis of relevant international conventions, eco-damage assessment methods and related researches in China and other countries. The methods are analysed for assessment principles and procedure, preparation stage, investigation contents and requirements, determining objects, scope and degree, value assessment contents and types of marine eco-damage, and for making plans of marine eco-restoration project. The paper puts forward the value of natural resources, and eco-damage should be calculated by the reasonable cost of restoration on the damaged ecosystem according to the eco-restoration plan and quantitative assessment methods. Two cases of sea reclamation project and oil spillage in China are analysed by this way. This will provide a scientific reference for establishing the compensation mechanism of marine eco-damage activities.

# SESSION 10 – REMOTE SENSING IN CONSERVATION MONITORING

**Chairs: Balázs Deák, Hermann Heilmeier**

Mapping the extension, location and nature conservation status of habitats is an essential part of biodiversity monitoring and designing conservation and management plans. The resulting maps providing data on the locality, size, shape and distribution and quality of habitats serve as a basis for nature conservation, management and land use planning. The need for spatially explicit and high standard data over large areas has been rapidly increasing in many sectors. Given the limited capacity of traditional field surveys, there is an urgent need for novel methods which can provide high-resolution and up-to-date data for nature conservationists and land managers. To fulfil these tasks application of remotely sensed data can be a viable solution. Remote sensing as an innovative technique is capable for acquiring synoptic data from extended areas, provides a faster map production, guarantees the repeatability of the methodology and can be used even in inaccessible, distant areas. Depending on the aims and the scale, end users can adopt the best fitting single- or multisensor techniques and the most feasible one from the many existing state of the art classification method. Remotely sensed data can effectively support ground surveys (for example by providing orientation maps, supporting the delineation of areas of interest) and can also provide data for evaluating remote sensing based species distribution, vegetation or habitat quality maps. Data provided by remote sensing is highly capable for supporting the planning of detailed restoration plans and also can be effectively used in the monitoring phase. We are dealing with presentations on the applications and future perspectives of remote sensing in restoration and nature conservation actions such as mapping species and habitats, exploring biodiversity and habitat quality assessments.

## HABITAT QUALITY AND CONSERVATION STATUS – WHAT REMOTE SENSING CAN TELL US ABOUT

András Zlinszky<sup>1</sup>, Balázs Deák<sup>2</sup>, Adam Kania<sup>3</sup>, Anke Schroiff<sup>4</sup>, László Bekő<sup>5</sup>, Norbert Pfeifer<sup>6</sup>, Hermann Heilmeier<sup>7</sup>

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Natura2000 mapping and habitat quality assessment is compulsory for EU member states under the Habitats Directive. Until now, various remote sensing (RS) data have been successfully used for deriving vegetation maps and some habitat quality parameters. In contrast, conservation status (CS) defined by the Habitats Directive is a complex parameter, composed by many different variables. Therefore, it was so far not possible to automatically derive it from RS data. We aimed to establish an automatic mapping of all CS variables for Pannonic alkali grasslands as required by Hungarian Natura2000 monitoring guidelines, using airborne laser scanning (ALS) data. A wide set of field references was used to calibrate the models relating ALS point cloud derivatives to habitat parameters and finally to CS. A classification software based on random forest machine learning and fuzzy class theory was developed to create maps of parameters relevant for CS. Following the Hungarian assessment scheme, proxies of these parameters were selected, and their weighted sum was calculated in GIS for generating categories of final CS score. As a result, the class probabilities predicted for various habitat types correlated well with naturalness and species composition. The correct identification of validation plots (80%) was comparable to field assessments. While adaptation to other sites still has to be tested, we conclude that ALS is a suitable data source for Natura2000 assessments in grasslands.

## USING LIDAR TO GAIN KNOWLEDGE OF VEGETATION-MICROTOPOGRAPHY RELATIONSHIPS OF POTENTIAL VALUE FOR CONSERVATION AND RESTORATION

Jesper Erenskjold Moeslund, Peder Klith Bøcher, Tommy Dalgaard, Lars Arge, Rasmus Ejrnæs, Bettina Nygaard, Mette Vestergaard Odgaard, Jens-Christian Svenning

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This presentation will cover three recent publications that all address the application of LiDAR (Light detection and ranging) data to gain knowledge on the relationships between microtopography and local vegetation patterns. Microtopography acts as a key driver of local plant diversity both in terms of distribution patterns, composition and species richness. Practical management and planning often take place at small spatial scales requiring detailed knowledge of the environment at local scale. LiDAR can provide exactly that covering large areas. Therefore, LiDAR is a promising technology to establish and map fundamental relationships between vegetation and the environment which is needed for effective conservation and restoration. This will be demonstrated using examples from both salt meadows, grasslands as well as a number of other habitats within the European NATURA2000 habitats network.

## APPLICATION OF AIRBORNE HYPERSPECTRAL IMAGES IN VEGETATION MAPPING OF COMPLEX OPEN HABITATS

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Open landscapes often hold a fine-scale mosaic of vegetation types, which makes mapping of these habitats highly cost- and labour-consuming by traditional field methods. We used airborne hyperspectral images for the vegetation classification in a complex open landscape comprising a high number of vegetation types from open alkali swards and steppes to marshes. We tested the accuracy of traditional image classifiers (maximum likelihood classifier – MLC), machine learning (support vector machine – SVM, random forest – RF), and feature extraction (minimum noise fraction (MNF)-transformation) on training datasets of different sizes. We defined 20 vegetation classes based on dominant species, canopy height and total vegetation cover. Image classification was applied to the original and MNF-transformed dataset with different training sample size. SVM and RF classifiers provided a high accuracy irrespective of the training area size both in case of original and MNF-transformed bands. MLC provided high accuracy with 30 training pixels (80.8%), but its accuracy decreased when using fewer training data (10 pixels; 52.6%). We suggest that for mapping of alkali landscapes, SVM is feasible, as it provided the highest accuracies. SVM was not sensitive for the training sample size, which is an advantage when only a limited number of training pixels are available from some classes. By using SVM with MNF-transformed bands we could provide an overall classification accuracy of 82.1%.

## ASSESSMENT OF DAM IMPACT ON LONGITUDINAL SEQUENCES OF IN-STREAM HABITATS

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Mesohabitat characterization (e.g. pools, riffles or other in-channel habitats) is a key issue for evaluating river physical status and their geographical adjustment, the latter being particularly sensitive to anthropogenic morphological changes. Most of the studies assessing morphological impacts of dams focused on emerged areas, but very few assessed impacts on flow channel, especially in riffles and pools. It is nowadays possible to extract water depth from aerial images, thus to characterize bedforms. The Ain River has undergone intensive damming until 1970 in its upstream section, causing morphological changes downstream. Along a 20-km reach, downstream of Pont d'Ain two sub-sections can be distinguished, the upper still impacted by the upper dams and the lower not yet affected. We hypothesize that riffle-pool sequence is underdeveloped in the first section since the dam construction, whereas no change yet occurred in the second section during the period. To test it, longitudinal water depth profile was extracted from aerial images taken in 1963 and 2012. Two complementary methods were then applied to analyse bedforms diversity thanks to signal processing: measure of depth variability and semi-automatic extraction of riffles and pools. Depth variability analysis confirms that the upstream section is effectively impacted by dams, and signal processing proves to be a good strategy to assess changes in pool and riffle frequency. Understanding morphological impact is challenging and important in order to locate and prioritize restoration actions. Such a methodological framework could be extended to a regional scale to meet manager expectations for targeting the implementation of the Water Framework European Directive.

## THE VISUAL ENVIRONMENTAL IMPACT ASSESSMENT OF THE RESTORATION OF THE DAMAGED LANDSCAPE STRUCTURE OF THE GARRAF LANDFILL SITE NEAR BARCELONA

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The process of landscape restoration in highly polluted areas is influenced by complex interactions among different environmental elements; these are interconnected through the comprehensive medium of the landscape structure which is made up of patches, corridors and matrices. In this study, we research the landscape structure of the Garraf landfill using an environmental monitoring model, configured with a unique visual environmental impact assessment platform. We evaluate a simulation from July 1999 to July 2014, and conclude that, at 5 m x 5 m resolution from the Unmanned Aerial Vehicle, and 30 m x 30 m resolution from the Landsat satellite (combining GIS, ENVI, Rhino and Grasshopper software), the model captures the main features of observed complex surface temperature, vegetation variables and explicit hydrology simulation in the landfill site. The change in the structure of this damaged landscape eco-system during the restoration process is noteworthy; the finer visual representation at different resolutions significantly improves the efficient and comprehensive assessment of the landfill restoration process. We conclude that there is great potential for improving the accuracy of the environmental impact assessment in restoration through using high-visualization models, and to develop such studies in the future.

## EFFECTS OF LOCAL HABITAT VARIABLES AND THEIR SPACING ON DISTRIBUTION OF EURASIAN BITTERN (*BOTAURUS STELLARIS*) BOOMING MALES: A REMOTE SENSING APPROACH

Janis Reihmanis<sup>1</sup>, Agris Brauns<sup>2</sup>, Jevgenijs Filipovs<sup>2</sup>, Roberts Silins<sup>3</sup>, Laura Zvingule<sup>1</sup>, Girts Strazdins<sup>1</sup>

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The study was conducted within the framework of the EU-funded LIFE+ project COASTLAKE (Restoration of Bittern habitats in two coastal lakes in Latvia, LIFE12 NAT/LV/000118). The goal of this study was to evaluate the role of habitat variables in determining distribution of booming males of Eurasian Bittern *Botaurus stellaris* in two lagoon-type shallow lakes in Latvia, Northern Europe. Mapping of distribution of booming Eurasian Bittern and current reedbed conditions was an integral part for planning habitat restoration activities and for developing implications for species conservation. Airborne hyperspectral and topographic LiDAR data from the two most important coastal lakes for the species – Lake Engure and Lake Pape – were used to assess habitats suitable for Eurasian Bittern. Reed density, reed productivity (categorised in terms of biomass produced) and classification of wetland habitats was based on laser scanning and hyperspectral image analysis. Bathymetric mapping and sub-bottom profiling data obtained with ground-penetrating radar also were considered for analysis of distribution of booming males. Our results provide concrete insights into habitat choice and spacing of Eurasian Bittern males in large wetlands. We will discuss importance of wetland habitat characteristics as correlates for the species distribution. This information is fundamental for any project aiming habitat restoration of species and for managing wetlands for nature conservation.



# SESSION 11 – BEST PRACTICE: METHODEN UND FALLBEISPIELE RENATURIERUNG

German Special Session, translated

**Chairs: Kathrin Kiehl, Sabine Tischew**

Best Practice: Methoden und Fallbeispiele zur Wiederherstellung und Renaturierung von Mooren, Grünland und Agrarlandschaften  
Gesetzliche Grundlagen wie die FFH-Richtlinie oder das Bundesnaturschutzgesetz umfassen nicht nur den Schutz von Natur- und Kulturlandschaften mit ihren Lebensräumen sondern fordern auch die Wiederherstellung degradierter und zerstörter Biotope und Lebensgemeinschaften. Da rein konservierender Naturschutz den anhaltenden Verlust an Arten und Biotopen nicht aufhalten konnte, spielen Renaturierungsmaßnahmen im praktischen Naturschutz inzwischen eine immer wichtigere Rolle. Mit dieser deutschsprachigen Session wollen wir Naturschutz-Praktiker/innen und Wissenschaftler/innen zu einem intensiveren Erfahrungsaustausch über aktuelle Themen der Renaturierungsökologie motivieren. Nur durch die wechselseitige Befruchtung von Wissenschaft und Praxis erwarten wir Fortschritte bei der Renaturierung bzw. Wiederherstellung von Ökosystemen inklusive ihrer charakteristischen Arten und Funktionen.

Die Session wird eröffnet durch einen Plenarvortrag von Dr. Peter Finck (BfN) zur EU-Biodiversitätsstrategie einschließlich des Ziels, 15 % der degradierten Ökosysteme bis 2020 zu renaturieren. Der Vortrag wird sich mit den Fragen beschäftigen, was vor diesem Hintergrund von der Renaturierungsökologie erwartet wird, wo Wissensdefizite bestehen oder zu welchen offenen Fragen bislang wissenschaftliche Fallstudien fehlen. Die folgenden Vorträge präsentieren dann Methoden der Renaturierung und Fallstudien aus verschiedenen Lebensräumen. Die Session schließt mit einem Forum, auf dem Möglichkeiten für einen intensiveren Austausch zwischen Wissenschaft und Praxis erörtert werden sollen.

## DIE UMSETZUNG DES 15% ZIELS DER EU ZUR RENATURIERUNG DEGRADIERTER ÖKOSYSTEME IN DEUTSCHLAND – EINE SITUATIONSANALYSE AUS SICHT DES BUNDES

Implementing the 15%-restoration target in Germany – a government perspective

Peter Finck

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Die EU-Biodiversitätsstrategie 2020 hat zum Ziel, den Verlust der biologischen Vielfalt und die Verschlechterung der Ökosystemleistungen in der Europäischen Union aufzuhalten. Die Strategie mit ihren sechs Einzelzielen dient zur EU-internen Umsetzung der globalen Verpflichtungen, die 2010 im Rahmen der 10. Vertragsstaatenkonferenz zum Übereinkommen über die biologische Vielfalt (CBD) eingegangen wurden. Im Einzelziel 2 wird u.a. die „Wiederherstellung von mindestens 15 % der degradierten Ökosysteme“ bis 2020 gefordert. Die EU-Mitgliedsstaaten sollen hierzu einen nationalen strategischen Rahmen entwickeln und Prioritäten für die Wiederherstellung von Ökosystemen setzen. Nach Auffassung der Bundesregierung stellt die Nationale Strategie zur biologischen Vielfalt (NBS) die Grundlage für das politische Handeln zur Umsetzung der EU-Biodiversitätsstrategie dar. Bei der Umsetzung des Ziels 2 der EU-Biodiversitätsstrategie zur Wiederherstellung degradierter Ökosysteme legt Deutschland die Priorität auf die „Moore“ und „Auen“. Durch diese Priorisierung sollen Synergieeffekte zwischen dem Schutz der Biodiversität, dem Klimaschutz und der Anpassung an den Klimawandel optimal genutzt werden. Der aktuelle Zustand von Moor- und Auenökosystemen in Deutschland wird beschrieben und Beiträge des Bundes zur Renaturierung dieser Ökosysteme vorgestellt. Die praktische Umsetzung von Renaturierungsmaßnahmen offenbart auch Wissensdefizite, die durch die Forschung aufgegriffen werden sollten.

## RENATURIERUNG VON AUENGRÜNLAND IM BIOSPHÄRENRESERVAT MITTELELBE

Restoration of floodplain meadows in the “Mittelbe” Biosphere Reserve, Saxony-Anhalt, Germany

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Das Ziel des LIFE+ Projektes „Elbauen bei Vockerode“ besteht in der Rückgewinnung von Überflutungsflächen der Elbe. Durch die Schlitzung des Gatzter Bergdeiches werden im Biosphärenreservat Mittelbe über 200 ha zusätzliche Überflutungsfläche geschaffen. In seiner Eigenschaft als Projektträger des LIFE+ Projektes erwarb der WWF Deutschland zuvor intensiv genutztes Ackerland in der Rückdeichungsfläche, das gemeinsam mit den Projektpartnern schrittweise in standorttypische Auenlebensräume umgewandelt wird. Auf dem überwiegenden Teil der Ackerfläche, etwa 45 Hektar, wird seit 2013 mit naturnahen Begrünungsverfahren Auengrünland etabliert. Bisher fanden Mahdgutüberträge von unterschiedlichen Spenderflächen und Ansaaten mit Samenmischungen zu verschiedenen Zeitpunkten in den Jahren 2013, 2014 und 2015 statt. In Abhängigkeit der durchgeführten Maßnahmen (Zeitpunkt, Methode, Qualität der Spenderfläche) entwickeln sich die behandelten Teilbereiche unterschiedlich. Auf den im Jahr 2013 durch Mahdgutübertrag begrüneten Flächen konnten bisher ca. 66 % der auf der Spenderfläche vorkommenden Arten erfasst werden. Die Erfolgskontrolle auf den im Jahr 2014 angesäten Flächen ergab, dass von 28 eingesäten Arten in der ersten Vegetationsperiode 82 % aufgelaufen waren. Für die Entwicklung der Flächen ist ein angepasstes Pflegemanagement von hoher Bedeutung. Aus den bisherigen Erfahrungen und Ergebnissen werden Praxisempfehlungen für die Renaturierung von Auengrünland abgeleitet.

## 20 JAHRE RENATURIERUNG VON STROMTALWIESEN AM HESSISCHEN OBERRHEIN

Restoration of floodplain meadows on the Rhine river, Hesse, Germany: A summary of 20 years experience

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1997 wurde erstmals am hessischen Oberrhein auf einer 1,3 ha großen Fläche in Riedstadt-Leeheim die Methode der Mahdgutübertragung angewendet, um im Rahmen einer Kompensationsmaßnahme artenreiche Stromtalwiesen neu anzulegen. Es zeigte sich nach wenigen Jahren, dass die Wiederansiedlung der seltenen Zielarten äußerst schnell und erfolgreich gelang, woraufhin von 2000 bis 2008 in zwei großen, vom Bundesamt für Naturschutz und der deutschen Bundesstiftung Umwelt geförderten Folgeprojekten weitere Stromtalwiesenbestände mittels der Methode der Mahdgutübertragung neu angelegt wurden. Seit dem Auslaufen dieser Projekte führt die Stadt Riedstadt das Projekt „Stromtalwiesen“ in eigener Regie weiter fort. So konnten von 1997 bis heute auf 80 unterschiedlichen Parzellen mit insgesamt 72,4 ha Fläche Renaturierungsmaßnahmen durchgeführt werden. Die wissenschaftlichen Begleituntersuchungen haben gezeigt, dass diese Maßnahmen hinsichtlich der Wiederansiedlung der seltenen Stromtalwiesen-Zielarten äußerst erfolgreich waren. Die letzte ausführliche Erhebung auf insgesamt 150 Dauerbeobachtungsflächen erfolgte im Jahr 2014. Dabei konnten auf den Renaturierungsflächen insgesamt 209 Arten höherer Pflanzen festgestellt werden, davon 36 der Roten Listen. Die Stadt Riedstadt ist seit dem Jahr 2000 an der Planung, Ausführung, Dokumentation, Überwachung und Organisation der Renaturierungsmaßnahmen und der landwirtschaftlichen Folgenutzung beteiligt, seit 2003 kümmert sie sich federführend darum und seit 2009 vollständig in Eigenregie. Weitere Informationen: [www.riedstadt.de/stromtalwiesen](http://www.riedstadt.de/stromtalwiesen)

## MOORE ALS FFH-LEBENSRAUMTYPEN – WIE KANN SICH DIE MOORRENATURIERUNG AUF DIE BEWERTUNG DER LEBENSRAUMTYPEN AUSWIRKEN?

**What is the effect of peatland restoration on evaluation criteria for Natura 2000-habitats?**

Cornelia Siuda

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Moorökosysteme werden unter verschiedenen FFH-Lebensraumtypen (LRT) subsummiert – je nachdem, ob es sich um Grundwasser- oder Regenmoore handelt und welche Nutzungseinflüsse sie überprägen. Die standardisierte Vorgehensweise bei der Erfassung der FFH-Lebensräume ist die Beschreibung der aktuellen Pflanzendecke und ihres Erhaltungszustandes. Allerdings sind Moore insbesondere durch den Bodenwasser- und Nährstoffhaushalt gesteuert. Zum Verständnis der Moorökologie, zur Einschätzung der Erhaltungszustandes und zum Erkennen von Veränderungen ist es nicht allein die aktuelle Vegetation, die durch den FFH-LRT beschrieben wird, sondern, in Ergänzung dazu, vor allem die Moorstratigrafie, die als „Gedächtnis“ des Moorstandortes eine wirkliche Bewertung der einzelnen FFH-Lebensraumtypen, wie auch in der Synthese, des gesamten Mooregebietes zulässt. Im Vortrag werden verschiedene Mooregebiete und Moorstandorte vorgestellt und der Vergleich zwischen aktueller Pflanzendecke (als LRT) und stratigrafischem Befund hergestellt. Dabei werden sowohl naturnahe als auch degradierte sowie renaturierte Moorstandorte betrachtet und (mögliche) Renaturierungsziele dazu in Beziehung gesetzt. Dabei zeigt es sich, dass die standardisierte Kategorisierung der LRTs hinsichtlich des Erhaltungszustandes im Vergleich zu den ökologischen Leitbildern einer Renaturierung vergleichsweise wenig detailliert ausfällt. Daher bedarf es konkreter ökologischer Bewertungskriterien, die im Rahmen eines Monitorings die Ergebnisse – und Erfolge – einer Renaturierung, je nach Moorstandort, verdeutlichen.

## MOORRENATURIERUNG DURCH DIE STIFTUNG NATURSCHUTZ IN SCHLESWIG-HOLSTEIN

**Peatland restoration by the Nature Conservation Foundation of Schleswig-Holstein, Germany**

Jutta Walter

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Durch die Förderung des Moorschutzprogramms des Landes Schleswig-Holstein kann die Stiftung Naturschutz seit 2011 in größerem Maßstab auf der Grundlage fundierter Erhebungen und Planungen Wiedervernässungsmaßnahmen in Mooren umsetzen. Der Schwerpunkt liegt dabei auf der Renaturierung ehemaligen entwässerten Hochmoorgrünlands, das in den letzten Jahrzehnten für den Naturschutz angekauft worden war. Systematisch angelegte Dämme entlang von Höhenlinien und in 20–30 m Abstand von Wegen verhindern das Abfließen des Niederschlagswassers auf der Oberfläche und im Moorkörper. Beim Bau der Torfdämme werden vorhandene Drainagen systematisch unterbrochen und das seitlich entnommene Material durch Überfahren mit Baggerketten verdichtet. Parzellengräben werden zusätzlich durch Stau gekammert oder vollständig überhöht verfüllt. So entstehen unterschiedlich große Einstaupolder, für die jeweils die Höhe des Wassereinstaus reguliert werden kann. Auffällig ist eine starke Rückquellung der Weißtorfe nach Wiedervernässung. Die Vegetationsentwicklung in den Poldern hängt stark von der vorherigen Nutzungsintensität und -dauer ab. Moorfrösche und Libellen sowie Kranich, Bekassine und Blaukehlchen profitieren schon in den ersten Jahren nach Maßnahmenumsetzung.

## AMPHIBIENINITIATIVE SCHLESWIG-HOLSTEIN: EIN PROGRAMM FÜR STRENG GESCHÜTZTE AMPHIBIENARTEN – ERFahrungen AUS 10 JAHRE UMSETZUNG

### Protection of highly endangered amphibians in Schleswig-Holstein, Germany: Experiences from a ten-year campaign

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Im Jahr 2003 wurde eine Kampagne gestartet, um gefährdete Amphibienarten zu schützen. Um die Ziele zu erreichen, wurden neue Verfahren eingesetzt. Die Umsetzung erfolgt in enger Kooperation mit der Dänischen Firma Amphi Consult. Das Vorgehen ist dabei wie folgt:

- Charakterisierung des Lebensraumkomplexes
- Defizitanalyse der Lebensraumkomponenten der jeweiligen Zielart
- Gestaltung der fehlenden Lebensraumkomponenten
- Populationsmanagement zur Unterstützung von kleinen Populationen oder zur Wiederansiedlung

Die Maßnahmen wurden überwiegend auf den Eigentumsflächen der Stiftung Naturschutz Schleswig-Holstein (derzeit 34.000 ha) umgesetzt. Bisher wurden mehr als 1600 Gewässer neu angelegt, wiederhergestellt oder saniert. Zusätzlich wurden Flächen für extensive Weidehaltung vorbereitet, Winterquartiere angelegt oder Rohbodenflächen geschaffen.

Die Maßnahmen wurden über verschiedene Projekte finanziert, z. B.:

- LIFE-Programm: LIFE-Bombina, LIFE-Baltcoast, aktuell über das SemiAquatic LIFE-Projekt,
- EU-kofinanzierte Projekte aus der zweiten Säule der GAP,
- sowie Ökokonten der Ausgleichsagentur, einer Tochterfirma der Stiftung Naturschutz Schleswig-Holstein.

Das Aussterben von Wechselkröte und Rotbauchunke wurde verhindert. Die negativen Bestandstrends der Rotbauchunke, des Laubfrosches, der Wechselkröte, des Moorfrosches, der Knoblauchkröte und der Kreuzkröte konnten in vielen Gebieten durchbrochen werden. Das Vorhaben läuft mit einem jährlichen Umsatz von etwa 1 Mio. Euro weiter.

## ERFahrungen ZUR WIEDERANSIEDLUNG GEFÄHRDETER ACKERWILDPFLANZEN IN EUROPA

### Establishment of rare arable weed species in Europe: An overview

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Dieser Beitrag gibt eine Übersicht über methodische Erfahrungen zur Wiederansiedlung gefährdeter Ackerwildpflanzen in Großbritannien, Frankreich, den Niederlanden und Deutschland. Eine erfolgreiche Etablierung wird demnach besonders durch eine verringerte oder gar keine Kulturdeckung im Ansaatjahr begünstigt. Auch die Wahl der Deckfrucht hatte großen Einfluss. So gediehen selten Ackerpflanzen vorzugsweise in winterannuellen Kulturen, manche Arten bevorzugten jedoch Sommerungen. In winterkalten Regionen erbrachte frühe Herbstsaat höhere Auflaufraten, im wintermilden England lieferte Spätsaat bessere Ergebnisse. Artabhängig wurden bei Saatmengen zwischen 50 und 200 Samen m<sup>-2</sup> eine erfolgreiche Etablierung bei vernachlässigbaren Ertragsverlusten erzielt. Mineraldüngung senkte die Etablierungsraten, Arten wie *Arnoseris minima* bildeten dabei keine Samen. Generell beeinflussten Herbizide seltene Ackerpflanzen negativ, bestimmte Dikotyle konnten jedoch vom Graminazideinsatz profitieren. Mehrjährige Untersuchungen legen nahe, dass sich solche Arten bei geeigneter Ausbringung und Bewirtschaftung längerfristig etablieren lassen. Die Effekte von Klee gras, die Etablierung von bisher kaum untersuchten Arten, z.B. saisonal vernässter Ackerstellen, und die Etablierung schwer kultivierbarer Sippen wie *Adonis aestivalis* sollten in Zukunft genauer untersucht werden.

## WIEDERANSIEDLUNG VON ACKERWILDKRÄUTERN AUF FLÄCHEN VON BIOBETRIEBEN IN DEN NATURRÄUMEN MÜNCHNER EBENE UND FRÄNKISCHER JURA

Re-establishment of rare arable weed species on organic farmland, Bavaria, Germany

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Vorkommen und Diversität von Ackerwildkräutern sind in vielen Regionen Europas massiv rückläufig. Eine natürliche Wiederbesiedlung geeigneter Ackerstandorte ist meist unwahrscheinlich. Das Praxisprojekt hat die Wiederansiedlung seltener und gefährdeter Arten auf biologisch bewirtschafteten Äckern der Naturräume Münchner Ebene und Fränkischer Jura zum Ziel. Auf insgesamt 12 Bio-Betrieben wurde in den Jahren 2014 und 2015 autochthones Saatgut von *Buglossoides arvensis* (L.) I. M. Johnst. s. l., *Consolida regalis* Gray, *Legousia speculum-veneris* (L.) Chaix, *Neslia paniculata* (L.) Desv. s. str., *Ranunculus arvensis* L. und *Silene noctiflora* L. ausgebracht. Die Samen wurden im Herbst, direkt nach der Getreidesaat, auf Flächen von 0,03 bis 0,75 ha oberflächennah ausgesät. Anfang Juni 2015 fand die erste Erfolgskontrolle im Naturraum Münchner Ebene auf den Einsaatflächen von 2014/15 statt. Die Zielarten konnten auf drei der vier Betriebe etabliert werden. Die durchschnittliche Gesamtdichte der Zielarten pro Aussaatfläche lag bei maximal 22 Individuen pro m<sup>2</sup>. Das Projekt zeigt, dass Bio-Landwirte durch freiwillige Maßnahmen einen großen Beitrag zum Ackerwildkrautschutz leisten können und ist ein Beispiel für die erfolgreiche Implementierung von Forschungsergebnissen in die Praxis. Das Projekt wird durch den Bayerischen Naturschutzfonds gefördert und von Neumarkter Lammsbräu sowie Bioland unterstützt.

## WIEDERHERSTELLUNG VON BIODIVERSITÄT IN AGRARLANDSCHAFTEN AM BEISPIEL VON MEHRJÄHRIGEN BLÜHSTREIFEN UND FELDRAINEN

Restoring biodiversity in agricultural landscapes by perennial flower strips and field margins

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In produktiven Agrarlandschaften können artenreiche Randstrukturen wesentlich zum Erhalt der biologischen Vielfalt beitragen. In einer fünfjährigen Feldstudie wurde die Vegetationsentwicklung von aufgewerteten Feldrainen und neu angelegten mehrjährigen Blühstreifen auf Blockversuchen dokumentiert. Im Spätsommer 2010 wurde ein grasdominierter Feldrain mit Bodenstörung und Ansaat von 49 regionalen Wildpflanzen aufgewertet; ein Teil der Fläche blieb unbehandelt. Alle Varianten wurden ab 2012 entweder Mitte Juni oder Mitte September gemäht. Bereits ab 2014 ging auf den spät gemähten Varianten die Deckung der angesäten Zielarten stark zurück, zugunsten von konkurrenzstarken Gräsern. Die im Juni gemähten Flächen waren dagegen auch im 5. Jahr noch von den Ansaatarten dominiert und zeigten einen vielfältigen Blühaspekt. Im Spätsommer 2010 bzw. im Frühling 2011 wurden auf einer Ackerfläche sechs Wildkräuter- und eine Kulturartenmischung angesät. Auch im 5. Jahr waren auf den wildkräuterreichen Varianten noch 85–100 % der mehrjährigen Arten vorhanden, während die konventionelle Variante nur einen geringen Blühaspekt aufwies und bereits ab dem 2. Jahr von Gräsern dominiert wurde. Der Blühstreifen wurde 2x jährlich in 15-cm Höhe gemulcht: Mitte März und gestaffelt Mitte Juni / Ende Juli. Damit wurde über die gesamte Vegetationszeit ein Blühaspekt gewährleistet. Aus den Ergebnissen wurden Praxisempfehlungen zur Anlage und zur Pflege von Feldrainen und mehrjährigen Blühstreifen abgeleitet.

## VERMEHRUNG UND WIEDERANSIEDLUNG GEBIETSHEIMISCHER WILDPFLANZENARTEN AUS DER SICHT EINES REGIONALEN SAATGUTPRODUZENTEN

### Regional propagation and establishment of native plant species: A seed producers's perspective

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Anfang bis Mitte der 1980er Jahre haben einige Pioniere angefangen, deutsches Wildpflanzensaatgut zu produzieren. Der Landwirtschaftsbetrieb Johann Krimmer Wildpflanzenvermehrung hat 1985 zum ersten Mal für diesen Markt die Wildpflanzentart „*Anthemis tinctoria*“ ausgesät und 1986 die erste Ernte eingebracht. Seit dieser Zeit sind die Anforderungen an die Qualität des Saatgutes deutlich gestiegen. Das Bundesnaturschutzgesetz mit der geltenden Fassung vom März 2010 schreibt die Verwendung des gebietseigenen Saatgutes in der freien Landschaft vor. Die EU-Richtlinie 2010/60 und die daraus resultierende Erhaltungsmischungsverordnung bilden den rechtlichen Rahmen von der Sammlung des Ausgangssaatgutes bis zum Vertrieb des produzierten Saatgutes. Eine staatlich legitimierte und überwachte private Zertifizierung sichert den Qualitätsstandard. Die größte Herausforderung für Produzenten und Inverkehrbringer ist es jedoch, die Regionalität des Saatgutes sicherzustellen, zumal die Zahl der zu produzierenden Arten – gerade auch für Naturschutz- und Renaturierungsprojekte – erheblich gestiegen ist.

## BEISPIELE INTEGRATIVER PFLANZENARTENSCHUTZPROJEKTE AUS SCHLESWIG-HOLSTEIN

### Examples for integrative plant-species protection projects in Schleswig-Holstein, Germany

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Jede zweite Blütenpflanze in Schleswig-Holstein (SH) steht auf der Roten Liste. Von jeder vierten Pflanzenart sind weniger als 30 Fundorte bekannt. Steigender Nutzungsdruck und fortschreitende Zerschneidung der Lebensräume führen zur Isolierung der Pflanzenvorkommen. Ergänzend zu Biotopschutz und Erhaltungsmaßnahmen wird diese Isolierung durch zeitlich begrenzte (Wieder-)Ansiedlungen mit autochthonem Saat- bzw. Pflanzgut reduziert. Neben dem Pflichtprogramm des behördlichen Pflanzenartenschutzes zur Verbesserung der Erhaltungszustände der FFH Anhang II Arten wird im Rahmen integrativer Projekte versucht, eine breitere Öffentlichkeit für den Pflanzenartenschutz zu gewinnen. Jährlich werden Saatgrußkarten an interessierte Bürgerinnen und Bürger versandt. Im landesweiten Projekt des LandFrauenVerbandes wurden 2007/2008 anlässlich des 60-jährigen Jubiläums über 60 Wildpflanzentarten wiederangesiedelt und in Patenschaften betreut. Öffentliche Institutionen werden motiviert, artenreiche Wiesen in Parkanlagen oder z.B. als Friedwiesen herzustellen. Pferdehalter werden unterstützt, artenreiches Grünland zum Heuwerb herzurichten. Eine vom Land eigens dafür eingerichtete „Artenagentur SH“ hilft verschiedensten Trägern bei der Projektentwicklung und -umsetzung. Finanzielle Mittel werden vom Land SH bereitgestellt. Saat- und Pflanzgut seltener Arten wird in der Archegärtnerei der Stiftung Naturschutz produziert.

## RENATURIERUNGEN MIT NATURNAHEN BEGRÜNUNGSMETHODEN IN BRANDENBURG

### Near-natural restoration in Brandenburg, Germany

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Der Vortrag gibt einen Überblick zu Renaturierungen mit naturnahen Begrünungsmethoden in Brandenburg. Vorgestellt werden u.a. großflächige Mahdgutübertragungen, Oberbodenübertragungen, Ansaaten und Pflanzungen auf Renaturierungsflächen der Kippen des Braunkohlenbergbaus in der Lausitz sowie Sodenversetzungen und Sodenübertragungen in Form von Rollrasen in Potsdam. Ein besonderes Augenmerk liegt zudem auf der Frage, ob ortsansässige Landwirte in naturnahe Begrünungen einbezogen werden sollten. An Praxisbeispielen werden die Vor- und Nachteile, die damit verbunden sind, erläutert. Kurz wird auch auf den Erfolg der einzelnen Maßnahmen eingegangen.

## GEWINNUNG UND EINSATZ VON WIESENDRUSCH ZUR WIEDERHERSTELLUNG UND AUFWERTUNG VON GOLDHAFERWIESEN - ERSTE ERFAHRUNGEN AUS HESSEN

### Harvest and application of threshed material for the restoration of golden oatgrass meadows, Hessa, Germany

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Ein Schwerpunkt des 2015 gestarteten Naturschutzgroßprojekt Vogelsberg ist die Wiederherstellung und Aufwertung von Berg-Mähwiesen (LRT 6520) mittels Samenübertragung durch Wiesendrusch. Zur Auswahl der Druschflächen wurden Ziel- und Störarten sowie die Samenreife erfasst. Ertragsausfall und Aufwand wurden den Bewirtschaftern individuell vergütet (Schnitt 360 €/ha). Der Wiesendrusch fand im 1. Aufwuchs vom 1.7. bis 7.8. statt. Zum Einsatz kamen Großflächenmähdrescher, ein über Tastkufen geführtes Pendelmähwerk ermöglichte Schnitthöhen <8 cm. In 19 Partien wurde auf 22,5 ha 1.600 kg getrockneter, ungereinigter Wiesendrusch gewonnen (LRT 6230, 6520, Übergänge 6510/6520, Nasswiesen). Die Druschkosten betragen durchschnittlich 406 €/ha Druschfläche bzw. 5,80 €/kg ungereinigtes Druschgut. Ergebnisse der Qualitätsuntersuchung präsentiert das Poster Dullau et al. (2016). Erste Ansaaten erfolgten im Herbst mittels Übersaat in bestehende Grasnarben, die durch Striegeln geöffnet wurden. Eine Saatmischung verschiedener Druschtermine berücksichtigt Bodenfaktoren und vorhandene Vegetation der Zielflächen. Gesät wurde im Verhältnis von 1:1 (Spenderfläche:Zielfläche). Durch die Varianten (i) Saat mit Striegeln, (ii) Saat ohne Striegeln, (iii) Striegel ohne Saat und (iv) Kontrolle soll der Effekt der Übersaat sowohl gegenüber einer reinen Aktivierung der Bodensamenbank als auch der natürlichen Entwicklung verglichen werden. Erste Ergebnisse der im Frühsommer 2016 durchgeführten Erfolgskontrolle werden präsentiert.



## LANGZEIT-BEOBACHTUNG EINER ALMWEIDE-REKULTIVIERUNG NACH WALD-WEIDE-TRENNUNG

**Long-term monitoring of mountain pastures established as forest-pasture substitutes, Austria**

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Begrünung von Grünland in mittleren und höheren Lagen stellt besondere Ansprüche an die verwendeten Saatgutmischungen, vor allem bei Anlage von Weideausgleichsflächen nach der Trennung von Wald und Weide: rasche und ausdauernde Vegetationsdecke zum Erosionsschutz, ausreichend Nährwert für Weidetiere und möglichst geringes Einbringen standortfremder Arten. In der Vergangenheit wurden bereits Versuche mit standortgerechtem Saatgut im Vergleich zu kommerziellen und standortangepassten Mischungen durchgeführt. In den ersten Jahren zeigt standortgerechtes Saatgut sehr gute Ergebnisse, Langzeitdaten liegen bisher aber nur wenige vor. Die Vegetation eines 1998 angelegten Begrünungs-Versuchs auf saurem Standort auf 1400 m ü. NN (drei Mischungen, eine Nullvariante; mit/ohne einmalige Kalkdüngung, Düngergaben in den ersten drei Vegetationsjahren, danach Weidenutzung ohne weitere Düngung), wurde 2014 erneut bonitiert und der Aufwuchs hinsichtlich Futterertrag geerntet und analysiert. Die einmalige Kalkdüngung zeigt nach 16 Jahren noch signifikante Unterschiede zu den nicht gekalkten Flächen hinsichtlich Gesamt-Deckung, Artenvorkommen und Futterwert. Unterschiede zwischen den Saatgutmischungen sind im Trend noch vorhanden. Die sauren und nährstoffarmen Standortbedingungen haben in Kombination mit fehlender Pflege dazu beigetragen, dass eine ausreichende Vegetationsdecke zwar noch vorhanden ist, Futterertrag und -qualität der gezielt angelegten Weidefläche allerdings deutlich abgenommen haben.

## STANDORTGERECHTE HOCHLAGENBEGRÜNUNG IN ÖSTERREICH – STAND DER TECHNIK UND AKTUELLE HERAUSFORDERUNGEN

**Site-specific re-vegetation at high altitudes in Austria – state-of-the-art and current challenges**

Bernhard Krautzer, Wilhelm Graiss, Silke Schaumberger

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In den letzten fünfundzwanzig Jahren kam es in den österreichischen Alpen zu einer rasanten Entwicklung der Technik bei der Wiederbegrünung in Hochlagen. Der Bagger hat die Planierraupe weitestgehend ersetzt, die Erhaltung und Wiederverwendung vorhandener Vegetation ist vielerorts eine Selbstverständlichkeit geworden. Zu Beginn der Neunzigerjahre des vorigen Jahrhunderts war Saatgut von standortgerechten subalpinen und alpinen Arten nur in „homöopathischen“ Mengen für Insider erhältlich. Mittlerweile werden mehr als zwanzig verschiedene Arten großflächig vermehrt und sowohl als Saatgutmischung für unterschiedlichste Standortbedingungen für montane bis alpine Höhenlagen als auch in Form fertiger alpiner Rollrasen in ausreichenden Mengen angeboten. Auch die Verwendung regionalen Saatgutes von passenden Spenderflächen findet zunehmend Einsatz in der Rekultivierung nach technischen Eingriffen. Der aus diesen Möglichkeiten entwickelte moderne Stand der Technik ist in Österreich inzwischen praktizierter Standard. In den letzten Jahren wurden auch ökonomisch tragbare Konzepte zur Begrünung von devastierten Schipisten in den Nördlichen Kalkalpen entwickelt.



## RENATURIERUNG VON FELSVEGETATION – EINFLÜSSE VON NEOPHYTEN UND LANDNUTZUNG

### Impact of neophytes and land use on restoration of rock vegetation in Bavaria, Germany

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Naturschutzfachlich hochwertige Pionier-Felsvegetation auf Diabas (Naturraum 411, Mittelvogtländisches Kuppenland) unterliegt störenden Einflüssen wie Verinselung, Stoffeintrag aus Agrarflächen und Überwucherung durch den Neophyten *Phedimus spurius* (*Sedum spurium*). Die Arbeit befasst sich mit der Renaturierung und dem Biotopmanagement durch *Phedimus spurius* stark beeinträchtigter Felsgrusrasen und der Abhängigkeit ihrer Diversität von der umgebenden Landnutzung. Die Diversität und Artenausstattung von Fels-Pioniervegetation innerhalb intensiv genutzter Ackerflächen ehemaliger Produktionsgenossenschaften, flurbereinigter sowie extensiv genutzter Umgebung im „Grünen Band“ werden verglichen. Einfache Versuche, Fels-Pioniervegetation an Autobahn-Sekundärstandorten anzusiedeln, wurden ausgeführt. Die Relevanz der durchgeführten Untersuchungen und Maßnahmen ergibt sich aus dem Status von Felspionier-Vegetation als FFH-Lebensraumtyp (LRT), geschützter Biotop nach §30 BNatSchG und Wuchsort gefährdeter Pflanzenarten der Roten Listen.

## ANLAGE VON SCHOTTERRASSEN MIT STANDORTGERECHTEM SAATGUT

### Creation of gravel lawns with site-specific seed mixtures, Austria

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Ein Schotterrasen als versickerungsaktive Oberflächenbefestigung hat bei Begrünung mit regionalem Saatgut einen hohen ökologischen Wert und ist besonders geeignet für Flächen mit geringer Verkehrsbelastung und ruhendem Verkehr. Er ersetzt blanke Schotter- oder Asphaltflächen, die nicht nur teurer in der Herstellung, sondern auch versiegelt sind. Durch die Wasseraufnahmefähigkeit und Verdunstung im Sommer wirken Schotterrasen-Flächen bei zunehmenden Starkniederschlagsereignissen hochwassermindernd. Neben der Neuanlage von Schotterrasenflächen besteht auch die Möglichkeit, bestehende Parkplatzflächen in Schotterrasen umzuwandeln. Voraussetzung dafür ist, dass die Tragfähigkeit und Wasserdurchlässigkeit des vorhandenen Aufbaus dem eines Schotterrasens entsprechen. Dabei wird Humus bzw. Kompost in bestehende Schotterflächen mit speziellen Geräten eingearbeitet. Der Erfolg einer solchen Maßnahme hängt vom verwendeten organischen Material, der Menge und dessen möglichst homogener Einmischung ab. Nach dem Einarbeiten des organischen Materials ist wiederum eine Verdichtung notwendig. Eine oberflächlich abgelegte standortgerechte regionale Saatgutmischung unter Zugabe eines Langzeitdüngers führt zu zufriedenstellender Vegetationsentwicklung, ausreichender Tragfähigkeit und optimaler Versickerungsleistung. Auf eine Pflege solcher Flächen kann weitgehend verzichtet werden.

# SESSION 12 – AN OVERVIEW OF ECOLOGICAL RESTORATION IN EUROPE

Chair: Jordi Cortina

Ecological restoration has become increasingly important in Europe, largely thanks to funding programs derived from European nature, development, cohesion and agricultural policies. In 2011, the European Union identified ecological restoration as a means to improve the status of “ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and wellbeing”. The CBD Aichi targets 14 and 15 were then incorporated into the European Biodiversity Strategy to 2020. Target 2 of this strategy aims at restoring at least 15% of degraded ecosystems in Europe by 2020. Under the Biodiversity Strategy 2020, member states committed to deliver a national Restoration Prioritization Framework (RPF) by the end of 2014 in order to improve the quality, scale and consistency of ecosystem restoration.

However, despite social demand and efforts from the European Commission, advances have been unconvincing. This lack of response may partly reflect poor knowledge on the current state of ecological restoration in Europe, and particularly, (1) the main actors and how are they organized in each member state, (2) the annual budget devoted to restoration projects, (3) the extent and quality of restoration, (4) the main species and habitats being targeted, (5) the legal framework that regulates this sector, (6) the governance structure, and (7) the hurdles and obstacles for the deployment of high quality restoration. In this session we compile structured information from various European countries to provide an overview of current status of ecological restoration in Europe, and to contribute to SER Europe web of knowledge. The outcomes of this session will be useful to the whole ecological restoration community by providing suitable examples and facilitating the access to existing information. We aim at incorporating other European countries in further short communications.

## RESTORATION POLICY DEVELOPMENTS ON EU AND INTERNATIONAL LEVELS

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The presentation will inform about policy developments on EU and international levels in the context of restoration. Target 2 of the EU Biodiversity Strategy implies that ‘By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15 % of degraded ecosystems’. At the 20<sup>th</sup> meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to the Convention on Biological Diversity, held in Montreal 25–30 April 2016, a *short-term action plan on restoration* was adopted by 496 official delegates from 109 countries. The contribution of restoration in both rural and urban landscapes to the achievement of the objectives and targets of many Conventions and Frameworks was highlighted (e.g. climate change mitigation and adaptation, disaster risk reduction). The plan contains four main groups of activities: (1) assessment of the opportunities for ecosystem restoration; (2) improving the institutional enabling environment for ecosystem restoration; (3) planning and implementation of ecosystem restoration activities; and (4) monitoring, evaluation, feedback and disseminating results. Restoration actions need the involvement of many sectors and thus are important for operationalizing biodiversity mainstreaming into practice. The use of nature-based solutions and the development of green infrastructure can help to step up restoration action and vice versa. The presentation will also examine the links to other policy areas and try to demonstrate the benefits that can be achieved for these areas through restoration.

## ECOLOGICAL RESTORATION IN THE CZECH REPUBLIC

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In the Czech Republic, there is no centralized policy regarding ecological restoration. The term itself is still poorly known and understood among politicians and decision makers. The only state institution dealing with ecological restoration is the Agency for Landscape and Nature Protection, belonging to the Ministry of Environment. This Agency coordinates several programs which can be partly considered as ecological restoration, namely Program on Landscape Care, and some activities under Operational Programs of European Union. The programs mostly concern only protected areas and predominantly grasslands and wetlands in the form of conservation management. In 1990, the program “Revitalisation of River Systems” was launched by the Ministry of Environment, but it was mostly technically oriented, and in most individual projects, ecological restoration was not considered. But there were a few exceptions in which degraded streams and their floodplains were successfully restored. The Czech Union for Nature Conservation (and several other NGOs) and several land trusts conduct particular projects of limited extent. Occasionally, some activities under AgroEnvi programs of the Ministry of Agriculture can be considered as ecological restoration, although they are not called that. In reclamation of totally destroyed sites such as mining sites, ecological restoration is still only a very marginal approach and technical reclamation largely prevails (in only about 1.5% of the disturbed area, ecological restoration has been applied). The exceptions are based on individual activities of decision makers, and are not supported by a central directive and by present legislation that generally favours technical approaches. Only just recently, due also to our activities, one law was changed such that at least 10% of the area disturbed by mining can be left to spontaneous succession, although only if it was agriculture land before.

## THE STATUS OF ECOLOGICAL RESTORATION IN FLANDERS (BELGIUM)

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Flanders is one of the most densely populated regions of the world. Preservation and restoration of its (semi-)natural ecosystems is very challenging, mainly due to the high degree of urbanization, fragmentation, eutrophication and altered hydrological conditions. We present an overview of the restoration efforts in the Flemish nature, water, agricultural, transport and spatial planning policies and identify the major bottlenecks for the deployment of high quality restoration.

## REVER, THE FRENCH RESTORATION NETWORK

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In the past few decades, restoration has widely developed thanks to a rather favourable context, in particular legally speaking and regulatory framework-wise both at the European and French levels. Rediscovering the mitigation hierarchy “Avoid, Minimize, Restore” written in a 1976 French law, and implementing the EU habitats directives or the E.U. water framework directive and various nation-wide or local incentive policies, thus led to the development of restoration. Restoration projects are nevertheless also confronted with administrative, socio-economic or technical barriers. The nature of restoration actions themselves implies to take into account their impacts, which can potentially be negative for biodiversity, through more or less heavy procedures. Considering local practices and perceptions is also important for the success of the restoration. Following the model of international networks, such as the SERI, the Francophone network for ecological restoration (REVER) aims at accompanying and at favouring the development of restoration by facilitating the relationships between the various stakeholders: scientists, site managers, etc., through the exchanges of knowledge and experiences. Among its actions, REVER organizes workshops. The diversity of the communications as well as of the participants illustrates the diversity of ecological restoration and restoration ecology stakeholders in France and will be presented.

## ECOLOGICAL RESTORATION IN HUNGARY – A RECENT OVERVIEW

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Ecological restoration is carried out in two main domains in Hungary: the first related to research and the second as a nature conservation measure. The previous is mainly done by research institutes and universities, rarely at large scale, while nature conservation measures are carried out by the national park directorates, frequently at larger scales. Research topics are initiated by academics and small-scale actions are financed by research grants, whereas nature conservation organizations and NGOs launch mainly EU financed restoration projects. It is difficult to estimate the budget devoted to restoration actions. Main financial support is assured by LIFE and other EU financed projects, but not all can be considered as restoration actions. Large scale grassland and wetland rehabilitation was carried out in the lowland, sodic lake rehabilitation was also initiated, and is still going on. Specie- specific interventions include threatened species conservation, rehabilitation and invasive species eradication programmes. At present, a project is started to develop the national restoration strategy and framework (as part of the green infrastructure strategy) to comply with the EU Biodiversity Strategy 15% restoration target, but its implementation is not defined at the moment. We introduce examples for both domains: results obtained by research based restorations, and also good examples of large-scale restorations done by national park directorates for nature conservation.

## ECOLOGICAL RESTORATION IN ICELAND

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In this presentation we describe the status of ecological restoration in Iceland, identify the main actors and drivers involved and specify major obstacles for the deployment of high quality restoration in the country. Iceland has undergone severe degradation and desertification since the onset of Norse settlement over 11 centuries ago. About 40% of the country is now a desert with limited vegetation cover, and soil erosion is still active on extensive areas. Organized soil conservation work spans more than a century, in many cases resulting in ecological restoration. A recent overview of ecological restoration in Iceland estimates that at least 2300 km<sup>2</sup> are restored or under restoration. Heathlands and grasslands are by far the most extensively restored habitats (>85%). Restoration of native birch woodlands is increasing, in part because of a large-scale woodland restoration project, Hekluskógar, aimed at enhancing ecosystem resilience in the vicinity of the active Mt. Hekla volcano. Rewetting of wetlands initially drained for agricultural production started in the late 1990s, but is still on a small scale. The Soil Conservation Service of Iceland, a governmental agency, has been the main actor of ecological restoration. Other important actors include other governmental agencies or publicly funded projects, semi-private energy companies, NGOs and farmers participating in governmental cost-share projects.

## AN OVERVIEW OF RESTORATION IN ITALY

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Environmental restoration in Italy has a long story, dating back to Etruscan and Roman time; the latter are famous for several legislative measures, such as the “lex luci spoletina” and many water projects. Interventions on the territory went on with specific effort during the Renaissance and after the Unification of Italy. Here, a brief historical excursus on the most important restoration projects for Italy is presented, followed by a focus on the actual state of the art. The most significant restoration projects in terms of numerousness, size, and technological innovation are addressed to face soil erosion and hydrogeological instability in the alpine, Apennine, Sicilian and Sardinian mountains. Landscape and forest restoration projects are important as well, some of them fully accomplished in agreement with eco-compatibility criteria, others inexcusable. Bioengineering projects along rivers and coastlines are crucial as well. Referring to the most important of these latter, target areas, stakeholders, investments and criticalities are reported and discussed.

## RESTORATION EFFORTS ACROSS THE MEDITERRANEAN BASIN: FROM A SILVICULTURAL TO AN ECOLOGICAL RESTORATION APPROACH

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Restoration efforts in the Mediterranean Basin have been changing from a silvicultural to an ecological restoration approach. Yet, to what extent the projects are guided by ecological restoration principles remains largely unknown. To analyse this issue, we built an on-line survey addressed to restoration practitioners. We analysed 36 restoration projects, mostly from drylands (86%). Unexpected restoration results (e.g. inadequate biodiversity) were reported for 50% of the projects and restoration success was never evaluated in 22%. Long term evaluation (>6 years) was only performed in 31%, and based primarily on plant diversity and cover. The overview of ecological restoration projects in the Mediterranean Basin revealed high variability among practices and highlighted the need for improved scientific assistance and information exchange, greater use of native species of local provenance, and more long-term monitoring and evaluation, including functional and ecosystem services' indicators, to improve and spread the practice of ecological restoration. We further analysed in more detail afforestation projects conducted in dryland areas in Portugal (Alentejo) over the last 40–60 years, based on Holm-oak, Cork-oak and Umbrella-pine. In ca. 50 sites, we assessed the plant community cover and diversity, soil characteristics, and quantified the ecosystem services delivered by the reforested areas.

## ECOLOGICAL RESTORATION IN SPAIN

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Spain has a long history of ecosystem degradation. It has also combated ecosystem degradation for a long time. For example, up to 4.2 million ha of forests were planted between 1940 and 1995 (15% of current forest area). These interventions do not always conform to SER definition of ecological restoration. Yet, their objectives often included the improvement in the provision of ecosystem services as drinking water, forage and soil protection. Until the early 21<sup>st</sup> century, ecological restoration programs were carried out by the public administration, who gradually adopted the principles of ecological restoration. However, the economic crisis led to a radical change in budget availability, stakeholder involvement and the type of restoration. Over the last two decades, Spain has built a diverse network of stakeholders interested in ecological restoration, who are not always well connected and coordinated. In this presentation, I will briefly review the recent history of ecological restoration in Spain, the structure of the ecological restoration community, the legal framework and the main challenges that we are currently facing.

## RESTORATION STRATEGIES FROM LATIN AMERICA: EXPERIENCES FOR EUROPE TOWARDS AICHI ECOSYSTEM RESTORATION TARGETS

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In 2010, the Conference of the Parties (COP) of the Convention on Biological Diversity (CBD) called upon signatory parties for adopting Aichi Biodiversity Targets before 2020. Target 14 and 15 include the Global commitment to restore ecosystem that provide essential services, and degraded land. Five years after launching this call the global progress is slow. Here we analyse in detail the progress made by 27 countries, representing 82% of Latin American and Caribbean region. The analysis is based on National Biodiversity Strategies and Action Plans (NBSAPs) and Fifth National Reports (5<sup>th</sup> NRs) presented to the CBD Secretariat after 2010. Ecosystem restoration has been incorporated into national governance instruments in 24 Latin American and Caribbean countries, except in Belize, Honduras and Saint Vincent and the Grenadines. However, the degree of achievement of Aichi Targets 14 and 15 is uneven. Thus, governance instruments to handle ecosystem restoration are notable in Colombia and Brazil. NBSAPs are good governance instrument for biodiversity conservation but show significant limitations to guide ecosystem restoration. Operational guidelines for conducting high quality restoration are accomplished by specific governance instruments, but many times restoration efforts are biased toward forests. In conclusion, advances in ecosystem restoration in Latin America and the Caribbean are insufficient to comply with international obligations, but there are strategies developed that Europe can learn from them.

## LIFE NATURE – CLOSING THE GAP BETWEEN APPLIED RESEARCH AND RESTORATION PRACTICE?

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LIFE Nature projects aim at an improved conservation status of endangered species and habitats including the EU-wide Natura-2000 network of protected areas. Within the scope of these projects, numerous restoration measures have been implemented and monitored, and thus considerable knowledge has been accumulated. In many LIFE projects research institutions have been involved especially in baseline surveys and monitoring of restoration measures. However, the co-operations could be further enhanced, as they provide substantial benefits for both – the projects and the applied science. The main bottlenecks of this co-operation are a low awareness of the research institutes about their potential involvement in LIFE, concerns about high administrative loads and low scientific quality of the data, while sometimes LIFE projects teams over-estimate their professional capacities. Without adequate capacities there is the danger that insufficient data are collected, incorrect statistical analyses are done and questionable conclusions presented. On the other side, there are many high-quality LIFE-born results of utmost importance for restoration science that are not adequately published. The main focus of the presentation is a positioning of LIFE as powerful resource for future research in ecological restoration. A closer cooperation of LIFE with researchers as associate partners (or subcontractors) would generate mutual benefits. The projects would produce more advanced surveys and reliable data, and the research institutes would help with the scientific evaluation of the projects and the dissemination of their results for an international audience. This would be a great step forward in best practice of ecological restoration.



# SESSION 13 – ECOLOGICAL RESTORATION IN URBAN AREAS

**Chairs: Roland Schröder, Valentin Klaus**

Ecological restoration in urban areas – good concepts and good practice  
Urbanization is an ongoing process and in 2030 about 80% of the European population will live in urban areas. While in some European regions cities are still expanding, in other parts of the continent they are already subjected to shrinking going along with urban space becoming available for new uses. Thus, both shrinking and expanding urban areas can be recognized as highly dynamic landscapes containing several potentially valuable habitats for wildlife, summarized as urban green infrastructure. Promoting this urban green infrastructure is often seen as one of the most relevant strategies facing urban environmental degradation and integrating ecosystem services and wildlife into urban landscapes. However, applied approaches improving ecosystem functions and services in the urban context cannot be adapted directly from ecological restoration of natural or semi-natural areas due to the specific anthropogenic context. Involving urban site conditions, habitat connectivity, and meeting the requirements of several urban stakeholders represents a special challenge for restoration projects. The aim of the special session is to show habitat-specific restoration with a strong focus on practice-orientated approaches. Depending on specific restoration goals we want to present possibilities and limits of restoration approaches in the urban context. The session invites all studies on a broad range of urban habitats aiming at the restoration and optimization of regional native biodiversity, recreation values for residents, sustainable resource management and further ecosystem services.

SESSION 13-01 – ECOLOGICAL RESTORATION IN URBAN AREAS

## SEEDS AND THE CITY – ABOUT THE IMPORTANCE OF USING NATIVE SEED MIXTURES FOR URBAN GRASSLANDS RESTORATION

Valentin Klaus, Martin Rudolph, Nils Stahlhut, Till Kleinebecker, Norbert Hölzel

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While cities massively expand, space for native biota in rural and natural areas drastically decreases, highlighting the growing importance of urban nature. Urban habitats provide a large number of social, financial, recreational, and environmental ecosystem services but can also support high biodiversity. Cities contain a large number of green spaces, brownfields and roof greenings which can potentially serve as habitats for native plant species. Despite this ecological potential, native diversity of urban habitats is mostly quite low due to missing source populations and dispersal limitation. In this context, widening the scope of ecological restoration to urban (novel) ecosystems is one of the most important recent challenges. In this talk we will give an overview about the current and potential plant-species richness of urban grasslands in different German cities and present results of an experiment to floristically enrich park grasslands. It turned out that small-scale disturbance and seeding with a regionally produced seed mixture strongly increased the number of vascular plant species, while seeding or disturbance separately did not yield comparable results. As a consequence, we recommend using regional seed mixtures in combination with sward disturbance to ecologically optimize urban grasslands – a simple but effective approach to support urban nature of different habitats types.



## TRIPLE BENEFITS FROM URBAN GRASSLAND RESTORATION TO PEOPLE, PLANTS AND BEES

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Urbanisation is a threat to biodiversity and largely influences grassland diversity in cities. Grassland restoration on novel urban sites is challenging due to environmental conditions that often differ from near-natural sites. Moreover, the question remains how urban people appreciate species-rich grassland and thus might support restoration efforts. We demonstrate multiple benefits of grassland restoration by integrating previous research on (1) grassland restoration on urban wasteland sites, (2) diversity of wild bee species on these sites, and (3) people's preferences for grassland with varying levels of species richness. (i) A 5-year experiment on urban wasteland sites revealed both plant species and plant traits in relation to restoration success. Despite difficult environmental settings (e.g. stony soil, human use of the sites), even species of special conservation interest were successfully established. (ii) A range of wild bee species used restored grasslands as habitats. Compared to ruderal grasslands and landscaped sites, grassland restoration positively influenced bees' abundances. (iii) Urban people generally appreciated extensively managed grasslands (i.e. meadows), with increasing valuation for plots with a low, medium and high species richness. We conclude that urban grassland restoration can hold multiple benefits for people and different groups of taxa when site conditions, restoration methods and species combinations are well considered.

## URBANCOWS – RESTORATION OF URBAN COASTAL MEADOW COMPLEX IN PÄRNU TOWN, ESTONIA

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The Coastal Meadow Nature Reserve situated in Pärnu town, Estonia, covers boreal coastal meadows and coastal lagoons listed as priority habitats under Annex 1 of the Habitat Directive even when located inside an urban environment, and is spread over more than 370 ha. The coastal meadows of Pärnu suffered from insufficient management due to the cessation of traditional activities, grazing and haymaking, caused by the change in agricultural practice during the 20<sup>th</sup> century. When unmanaged, those areas overgrew with reed and bushes, degrading the conservation status of coastal meadows by directly causing the loss of biodiversity. Also, most of the coastal lagoon were in poor conservation status due to overgrowth, eutrophication, polluting with garbage and wastewater. The main objectives of the project LIFE+ URBANCOWS during five years (2012–2016) of its implementation are the removal of unwanted vegetation and reintroduction of traditional management – cattle grazing – on 220 ha of urban coastal meadows; restoration of the water regime of ca. 70 ha of coastal lagoons; building the visitor infrastructure and implementation of a publicity campaign. These goals are achieved by now. Evidently, reintroducing grazing was efficient to stop the biodiversity loss in this protected area, which is a challenge in the urban environment. Previous experiences gained during the last decade in restoration of such seminatural areas that suggest that the most cost-effective method is mechanical removal of old reed and bushes, followed by immediate reintroduction of cattle grazing, were once more confirmed.

## ECOLOGICAL AND SOCIO-ECONOMIC CONDITIONS OF MEADOWS RESTORATION IN THE MULTIFUNCTIONAL LANDSCAPE OF URBAN FLOODPLAIN

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The presentation shows the assumptions, conditions and practice of a project of floodplain meadows restoration in Warsaw. The project was implemented by the city council in cooperation with the University of Warsaw. The area of the project covered ca. 70 ha of floodplain, dominated by invasive species such as *Solidago gigantea* and *Acer negundo*. The main aim of the project was to reduce invasive species and to increase the biodiversity of species of plants, birds and pollinators. An additional effect is greater suitability for recreation and relaxation, aesthetic and social functions of floodplains, especially in the case of the “river of flowers” sown in one of the most visited places on the Vistula River in Warsaw. Methods of restoration have been chosen after analysis of vegetation and soil chemistry and after germination test on pilot plots. The results of tests on pilot plots show that the success of germination of meadow species depends on soil preparation – the number of seedlings was high on the plowed plots and plots of the removed topsoil, and significantly lower in the plots without soil preparation treatments. Limiting the growth of invasive (alien) or expansive (native) species also depends on the method of preparation of the soil - removal of topsoil limits an expansion of *Solidago gigantea* and *Agropyron repens*. The ploughing effectively limits expansion of *Calamagrostis epigejos*. Species such as *Acer negundo* and *Erigeron acris* germinate regardless of the method of preparing the soil. Preliminary studies of the chemistry of the soil indicate that the removal of topsoil approached habitat conditions to the source areas.

## RELATIVE CONTRIBUTIONS OF NOVEL AND REMNANT ECOSYSTEMS IN DETERMINING THE SPATIAL DISTRIBUTION OF RARE AND ENDANGERED PLANT SPECIES IN URBAN ENVIRONMENTS

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The importance of cities for nature conservation is growing as urbanization is increasing worldwide. The question on whether some plant species occur in them despite of the city or because of it still remains. In this paper we assess how the novelty of an ecosystem shapes the spatial distribution of numerous populations of different rare and endangered plant species. 3,500 populations of target species were precisely mapped throughout the whole state of Berlin, from which information on species, population status and size and nearby vegetation was recorded. Added to this, the city was divided into 80,000 different areas comprising 1,700 different ecosystems. Taking into account ecological, present and historical land use data, each of these areas was classified into different categories according to their novelty. Linking the different populations of target species with the novelty of the ecosystem they occur in allowed us to unravel the change in (i) total number of populations, (ii) population status, (iii) total number of species, (iv) plant types and, (v) species composition throughout the different gradients of novelty of the ecosystems. Results show that there is a general trend in rare and endangered plant species to prefer natural remnants and hybrid ecosystems over more novel ones, especially in the case of non-herbaceous perennial plants which have slow growth and reproductive cycles, and which are more susceptible to the constant changes in the urban matrix. More than half of all populations preferred ecosystems with a low degree of novelty, which were also higher in species diversity and with better population status as compared to more novel types.

## ROOFS FOR BIODIVERSITY – THE POTENTIAL OF NATIVE PLANT SPECIES FOR EXTENSIVE ROOF GREENING

Roland Schröder, Vera Straub, Kathrin Kiehl

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Up to now, extensive roof greening has been done mostly by species-poor plant mixtures (*Sedum*-roofs) often containing non-native plant species and cultivated varieties of native plants. However, aiming to preserve and increase regional native phytodiversity, roof greening measures can be improved by using the regional cultural landscape's potential for native plant diversity. As extensive green roofs often exhibit environmental conditions similar to dry grasslands (habitat template approach), we screened plant species of historically developed acidic dry grasslands (Koelerio-Corynephoretea) for roof greening in Northwest Germany. We tested the suitability of seed mixtures containing 25 plant species from regional native plant production and raked plant material from dry grasslands for roof greening in experimental miniature-roofs with 9-cm substrate layer thickness. All sown plant species established and partially reproduced generatively in the first growing season. Total vegetation cover was about 45% six months after sowing. The introduction of raked material increased target species richness by five vascular plant species, five moss- and seven lichen species. In this talk we will present results of the second growing season and give recommendations for the creation of biodiverse extensive green roofs by using native plant material.

## DEVELOPING A NEW URBAN GREEN INFRASTRUCTURE: GREEN ROOF INVENTORY AND POTENTIAL ANALYSIS WITH REMOTE SENSING TECHNOLOGY

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Green Roofs can help to adapt cities for climate change, through the provisioning of cooler microclimates and reduced stormwater run-off. They also enhance biodiversity in urban ecosystems. In order to evaluate these positive effects in a quantitative way, information about the already existing Green Roofs and potential Green Roof sites are needed. The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt DLR), the German Roof Gardener Association (Deutscher Dachgärtner Verband DDV) and different German cities developed a method with which existing Green Roofs and potential roof areas can be identified and inventoried from a "birds-eye view". The project received funding from the German Federal Environmental Foundation (DBU). The remote sensing technology uses high resolution satellite or airborne optical imagery (visible and infrared), DSM (Digital Surface Model) height information and existing building outlines maps (footprints), to estimate the percentage of vegetated areas on building roofs and to identify potential Green Roof sites. The results are impressive. For example, the total Green Roof area in Munich exceeds 4 million m<sup>2</sup>. However, there are still large areas of flat roofs (13.2 million m<sup>2</sup>) in the Bavarian Capital that offer potential for the installation of Green Roofs. The new remote sensing technology provides municipalities with the opportunity to use this data for urban planning decisions in the field of climate modelling, drainage system calculation and biodiversity networks.

**“BEE HOTELS” IN TOWN – A GOOD WAY TO PROTECT POLLINATORS?**

Maciej Ziemiański

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Assessment of the population of pollinators in the city is a big challenge. The city is a place that is changing in a dynamic way, and this strongly affects the pollinators. This project is designed to enable the assessment of if the pollinators colonize “bee hotels” at random, whether it is conditioned by the surrounding urban space. The object of the research was more than 500 wooden hotels for insects located in Warsaw, the Polish capital. The obtained preliminary results (after the first year of the project) indicate that the surrounding environment has a significant impact on the level of colonization hotels by solitary bees. The degree of occupancy of hotels was higher near allotment gardens, than in other places. Was found that the species of tree on which hangs a hotel for insects may be important for beetles colonizing it. The best tree species to hang the hotel were linden. Based on the results of observations it can be stated that the bee hotels were partly used by pollinators in urban areas in the first year after hanging. Undoubtedly, more research is needed to determine whether such a relationship will change in a dynamic urban environment.

**TEMPORAL RE-VEGETATION OF DEMOLITION SITES – A CONTRIBUTION TO URBAN RESTORATION**

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In a global context urbanization is an increasing phenomenon. In many German cities, however, the demolition of industrial and military infrastructure has created large areas of brownfields, which are used for city conversion processes. Urban brownfields of early-successional stages are often valuable for local and regional native biodiversity, but do not have good reputation in urban society due to sparse and flower-poor vegetation and large areas of bare ground mostly consisting of rubble. In 2014, we started an experiment on a temporally available demolition site by sowing two different native plant seed mixtures containing annual arable weeds and species from regional ruderal and mesophytic grasslands. The aim of the study was to enhance aesthetic appearance of young and only temporal available brownfields, to conserve regional native plant biodiversity and to mitigate invasion of non-native plant species. Our results indicate that introduced species should be able to cope with heterogeneous pH and nutrient-poor soil conditions. Sown species established well and introduced annuals created colourful vegetation aspects already in the first year. Introduced legume species were the dominant functional group during the second season both on sown and control plots. Sowing reduced the cover of non-native invasive species and Red-List species from spontaneous vegetation. This means that urban restoration should use both approaches with and without species introduction.

# SESSION 14 – GREEN-BLUE INFRASTRUCTURE

**Chair: Aisegül Syrakaya**

In cities and industrialised landscape, humans and wildlife compete for space, and challenges by climate change and pollution are immense. Ingenious urban planning is required to create and maintain networks of greened areas and water for the well-being of man and biota. These networks can be composed of restored ecosystems, reclaimed former industrial sites, ecosystems newly developed on urban sites and artificial substrates. Participatory planning can help to reconcile diverse stakeholder interests, and ensure social sustainability. This session will give new insights on legal and practical aspects of green-blue infrastructure planning in Middle Europe and Japan.

## INTERNATIONAL TARGETS AND RESTORATION IN URBAN AREAS

Aysegül Sirakaya

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Cities will be hosting 66% of the world's population by 2050. Because of climate change, cities will by then become much more vulnerable to extreme heat due to grey infrastructure. The lack of green spaces and green infrastructure (GI) in cities will continue to cause many problems regarding air and water quality and human health. Urbanisation will also result in a decline of rural areas to make room for the growing urban population, leading to further loss of biodiversity and ecosystem services (ES). Urban biodiversity conservation and restoration of ES could help overcome this. Within city scale, there are several opportunities to green urban living, through GI and larger nature areas such as parks and nature reserves. There are several international and EU targets for restoring ES as well as creating sustainable living in cities (Sustainable Development Goals 11 on sustainable cities and 15 on halting biodiversity loss; Aichi Targets 14 on ES and 15 on restoration; EU Biodiversity Target 2 on restoration and GI). This presentation will elaborate on the abovementioned legally non-binding targets at international and EU level in order to explore whether or not these targets are enough to facilitate the restoration of ES in urban areas as swiftly as they are needed. Secondly the presentation will review and assess the legally binding instruments on biodiversity at international and EU level in order to see if there are sufficient existing mechanisms for restoration of ES in urban areas. Thirdly, the presentation will strive to map national practices from the states that introduce legal schemes for urban ES.

## REVITALIZING POST-INDUSTRIAL LANDSCAPES THROUGH GREEN INFRASTRUCTURE (GI) IN JAPAN

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This paper presents the barriers and drivers in revitalizing post-industrial landscapes through the application of Green Infrastructure (GI) in Japan. Recently, GI is attracting a lot of attention in various fields regarding disaster prevention and creating resilient cities. Generally, GI has multi-functional elements that help restoring biodiversity and ecosystems compared to existing other types of infrastructure. In addition, GI is one of the effective solutions for reusing brownfields, which include an increasing number of unused derelict lands such as former factory sites in shrinking cities in the face of changing industrial structure. Some western countries have regenerated brownfields by using GI. For example, IBA Emscher Park in Germany has been restoring the natural environment in former industrial areas. However, values of GI in revitalizing post-industrial landscapes are little recognized or discussed in Japan. This study conducted a literature review and semi-structured interviews with local authority representatives in order to identify site history, legal frameworks, urban planning system, on-going activities, and stakeholder's perception in four case study sites in Japan. The four case study sites are all located in the Osaka bay area, which has faced a lot of problems resulting from an increasing number of unused lands often found in former factories and landfill sites in the context of shrinking cities. This paper concludes with presenting the barriers and drivers to using GI in revitalizing post-industrial landscapes in Japan.

## APPLYING THE GREEN INFRASTRUCTURE CONCEPT FOR REGENERATING THE REGION AFFECTED BY THE NUCLEAR ACCIDENT IN THE FUKUSHIMA PREFECTURE

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This paper discusses the role of green infrastructure (GI) in restoring severely contaminated sites and revitalising environmental and socio-economic functions of areas damaged by radioactive fallout due to the explosion at the Fukushima Daiichi Nuclear Plant in 2011. Some of the districts affected by the nuclear accident were already suffering, even before the disaster, from demographic shrinkage and ageing, which are common issues found in other rural regions in Japan. This accident imposed further difficulties on initiating a sound plan for regeneration. Given this problematic circumstance, the use of the GI concept might be one of the possible solutions for suggesting sustainable land use in such a region. The purpose of our study is to develop a conceptual model of applying GI to the region affected by the nuclear accident from the view of restoring landscape, regenerating agricultural products and flowers with reference to 'Satoyama' which is the community-led initiative to utilise and manage their surrounding natural environment in Japan. Our target sites were small villages where resident representatives and academic institutions have been collaborating to explore approaches to the regeneration for the last five years. In the face of uncertain outcomes, it is a difficult task to set up a mechanism for the adaptive process management for ecosystem restoration and sustainable strategies for socio-economic regeneration. Key challenges are how to overcome the reputational damage caused by radioactive contamination, to mediate different regeneration activities taken by individual stakeholders, and to revitalise the affected shrinking districts through imitating GI related businesses for the purpose of bringing younger people back to re-establish the local infrastructure.

## RESTORATION OF URBAN NATURE IN SYNERGY WITH CLIMATE ADAPTATION

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In urban areas, climatic changes in terms of extreme rainfall and heat create uncomfortable situations for citizens as well as damage to physical structures such as houses. In Denmark, this crisis has led many municipalities to develop climate adaptation schemes and to restore blue-green infrastructure in order to create a buffer for the extreme weather. In most blue and green restoration projects in Denmark, the main purpose is climate adaptation; however, there is a great potential and interest in achieving positive effects for biodiversity as well. An example of a climate adaptation project in Copenhagen is presented, where a small wastewater-polluted stream and its surroundings are planned to be developed into a rain water retention area with high biodiversity and recreational values as well. An essential first step applied in the planning of this urban restoration is a detailed survey of existing and previous flora and fauna. Additionally, close planning with engineers and authorities has been carried out in order to reach a holistic solution that satisfies several ecosystem services. Through the cooperation with landscape architects, design and biological premises for self-sustaining ecosystems have been combined into a detailed project plan with a high diversity of environmental gradients and niches. Results from the project will be presented together with examples of other initiatives in Denmark that integrate urban development, climate adaptation and biodiversity actions.

# SESSION 15 – CONSERVATION IMPORTANCE OF EARLY-SUCCESSIONAL STAGES IN RESTORATION OF HUMAN-MADE SITES

**Chairs: Klara Rehounková, Robert Tropek**

Conservation importance of early-successional stages in restoration of human-made sites Various human-made sites have been robustly evidenced to offer crucial secondary refugia for numerous threatened species. On the other hand, it is obvious that not all the species have similar chance to successfully colonise artificial habitats, moreover these patterns can differ among particular taxonomical groups and are further modified by environmental filters. This session will focus on species specialised on early-successional open habitats whose natural environment is recently vanishing from many European landscapes. Simultaneously, they are often reported to constitute a significant part of newly established habitats in highly-disturbed sites, such as (post)mining areas, industrial deposits, brownfields and other human-made sites. We aim to compare conservation potential of early-successional stages in human-made sites for different taxa groups and to evaluate general conservation value of such habitats which should be crucial for setting off general restoration priorities. Recently, spontaneous succession seems to be gradually accepted as a low-cost restoration tool with high conservation benefits in many human-made sites. However, such approach does not take account of needs of early habitats specialists and, sooner or later, leads to their local extinction. We thus would like to discuss available data concerning various ways how to block, slow down and/or even return back succession through introduction of additional disturbances to restoration practice in order to support early-successional specialists.

SESSION 15-01 – CONSERVATION IMPORTANCE OF EARLY-SUCCESSIONAL STAGES IN RESTORATION OF HUMAN-MADE SITES

## CONSERVATION POTENTIAL OF HUMAN-MADE SITES: A WASTELAND OR NOAH'S ARK FOR THREATENED HIGHER PLANTS?

Klára Řehounková

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Despite the immense impact of anthropogenic disturbances on landscape, such newly created sites give rise to valuable open habitats, which have become very rare in recent landscape. The restoration methods used afterwards lead either to their fast elimination (e.g. reclamation) or maintenance of their value for nature conservation (e.g. spontaneous succession). We studied the conservation potential of 18 successional seres occurring in various post-mining and urban sites, abandoned fields, emerged bottom of water reservoir, artificial fishpond islands and disturbed forests (fire, air pollution) across the Czech Republic in central Europe. In total, 2755 vegetation samples containing 890 higher plant species were analysed. We recorded 207 species of national Red List (24% of the total), including 13 (1%) critically endangered, 25 (3%) endangered, 83 (9%) vulnerable and 86 (10%) of lower risk species. The highest species richness of threatened species was established in nutrient poor post-mining habitats (limestone and basalt quarries) surrounded by diverse and well preserved natural habitats, while the lowest number occurred in sites with topsoil layer preserved, and surrounded prevalingly by urbanized or homogenous landscapes (road verges). In the majority of seres, early- and middle-aged successional stages without continuous tree cover (up to ca. 20 years since site abandonment) hosted an increasing number of threatened species. This trend was shown also in several late woody stages (more than 40 years since site abandonment) of various seres. Spontaneous succession is an effective restoration method but without additional disturbances can lead to the suppression of habitat heterogeneity and a decline of threatened specialists of open sites.



**CONSERVATION VALUE OF YOUNG HABITATS: ARE NATURAL PROCESSES IN POST-INDUSTRIAL SITES THREATENING ENDANGERED ARTHROPODS?**Robert Tropek<sup>1,2</sup>, Milan Rezac<sup>3</sup>, Filip Tichanek<sup>2,4</sup>, Jiri Benes<sup>2</sup><sup>1</sup>Charles University, Faculty of Science, Prague, CZ, robert.tropek@gmail.com<sup>2</sup>Czech Academy of Science, Institute of Entomology, Biology Centre, Ceske Budejovice, CZ, robert.tropek@gmail.com<sup>3</sup>Crop Research Institute, Prague, CZ<sup>4</sup>University of South Bohemia, Faculty of Science, Ceske Budejovice, CZ

Various post-industrial sites have been repeatedly shown as crucial secondary surrogates of threatened biodiversity of arthropods. On the other hand, it is obvious that only a part of the threatened species is able to effectively colonise novel human-made habitats. This contribution will summarise analyses of datasets from national mapping schemes of spiders and butterflies in the Czech Republic in relation to successional gradients specialisation. The robust data showed that an overwhelming majority of the most valuable species found in various post-industrial sites are highly specialised for young habitats. These facts will be confronted with the common practise of restoring disturbed sites, with a specific focus on technical reclamation and spontaneous succession, so far the two most common restoration practices in Central Europe. Technical reclamation usually eliminates young bare habitats by introducing nutrients and diaspores and thus prevents the majority of the specialised threatened species from effectively colonising secondary habitats. On the other hand, natural processes of spontaneous succession will sooner or later result in complete overgrowing of the site. Considering the generally high endangerment of many young habitat specialists in Central Europe, controlled disturbances seems to be a necessary supplement of many restoration projects in human-made sites if their conservation potential is to be fully utilised.

**EARLY-SUCCESSIONAL STAGES IN RECLAIMED MINE SITES IN SPAIN: ARE THEY WORTH TO BE PRESERVED?**Josu G. Alday<sup>1</sup>, Rob H. Marrs<sup>2</sup>, Carolina Martínez-Ruiz<sup>3</sup><sup>1</sup>Universitat de Lleida, Lleida, ES, jgalday@pvcf.udl.cat<sup>2</sup>University of Liverpool, Liverpool, UK<sup>3</sup>Universidad de Valladolid, Valladolid, ES

Early-successional stages are a normal output for a lot of reclamation programs. However, their ecological interest has been underestimated because restoration ecology has traditionally placed the target on mid- or late-successional stages. Nowadays, land use changes have reduced the number of early-successional areas in some regions. In this context, our aim was to test whether restoring early-successional stages is of some interest to preserve certain ecologically significant species. Here, we synthesised information from long-term monitoring programs and vegetation experiments carried out during the last 12 years on reclaimed mine sites in northern Spain (Palencia). These open-pit coal mines were reclaimed using a combination of top-soiling (mixture soil-manure) and hydroseeding with grasslands species. We established permanent plots to follow vegetation and soil dynamics, and an experimental design where we tested different tree and shrub seeding and planting procedures. Our results show that early-successional stages in these Mediterranean areas are very easy to achieve and maintain (cost-effective restoration). These early stages are mainly grasslands and rocky lands dominated by high numbers of plant species, but providing a great number of services (i.e. pasture for native grazers like deers and Roe deers, ponds for birds and amphibians). Surprisingly, after 9–10 years, the presence of some orchids increased the ecological interest of these grasslands. Thus, these areas are able to produce new ecosystem services with interest to the conservation community and society. Here, we discuss the implications of these findings for developing different restoration management plans and new research approaches.

## IMPACTS OF A SOIL TRANSFER FOR THE RESTORATION OF A MEDITERRANEAN GRASSLAND AFTER A PIPELINE LEAK: IMPORTANCE OF YOUNG SUCCESSIONAL STAGES

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In 2009, an oil leakage polluted a 5.5 ha area in a Mediterranean steppe (La Crau, Southeastern France). In 2010, the polluted soil was excavated and evacuated into a specialized centre. In spring 2011, 72,000 t of soil with the same characteristics were transferred from a nearby active quarry. The soil was transferred during a rainy period using direct translocation with substituting one replaced soil unit for one removed soil unit. The main soil layers were reconstituted in their different degrees of profile complexity, as derived from the original pedogenesis in the reference undisturbed soil. This process enabled us to evaluate the regeneration of steppe plant communities according to different treatments involving partial or total reconstitution of the soil profile. Nine quadrats (4 m<sup>2</sup>) were placed at random for each treatment and controls: “topsoil” (compacted or not) comprising altered bedrock + subsoil + topsoil; “subsoil” containing altered bedrock + subsoil; “altered bedrock” containing only altered bedrock (negative control); and “steppe”, the reference undisturbed soil (positive control). After 6 years, no treatment has reached a total success of ecological restoration. However, treatments, especially those with the topsoil, are close to the reference steppe vegetation in terms of composition and species-richness but not in terms of plant community structure. The “altered bedrock” has the poorest vegetation included only pioneer species with high ecological requirements. Our results show the importance of the transfer of soil seed bank contained in the upper soil layer for enhancing quickly the regeneration of the steppe vegetation and then to improve its restoration in shorter times.

## MICRO-TOPOGRAPHY DRIVEN SUCCESSION IN EARLY- AND MID-SUCCESSIONAL RECOVERING GRASSLANDS

Balázs Deák<sup>1</sup>, Orsolya Valkó<sup>1</sup>, Péter Török<sup>1</sup>, András Kelemen<sup>1</sup>, Tamás Miglécz<sup>1</sup>, Szilárd Szabó<sup>2</sup>, Gergely Szabó<sup>2</sup>, Béla Tóthmérész<sup>1</sup>

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We tested the effect of fine-scale micro-topography on plant diversity during the recovery of alkali grasslands. We studied the initial vegetation of six recently filled (1-year-old), and established vegetation on six old (7-year-old) filled channels surrounded by alkali vegetation in Hungary. Channels were filled by local soils originated from their dams. We hypothesised that (i) recently filled channels are characterised by a high cover of ruderal species and high species diversity and (ii) high micro-topographic heterogeneity, expressed by the elevation range of the plots, increases diversity in early stages but later on this effect diminishes. We found that diversity of species and plant strategy types was higher in recently filled channels compared to old filled ones. Micro-topographic heterogeneity had no effect on the studied vegetation parameters in recently filled channels. Conversely, in old filled channels, higher micro-topographic heterogeneity resulted in higher diversity and a lower cover of the dominant grass *Festuca pseudovina*. In old filled channels higher micro-topographic heterogeneity resulted in increased ruderality and decreased stress-tolerance, but it did not increase the diversity of plant strategy types. In contrast with former studies, we found that micro-topographic heterogeneity expressed even in a couple of centimetres had no effect on vegetation in early assemblages, but supported a high diversity in later successional stages. Thus, in grassland restoration projects, micro-topographic heterogeneity has a crucial role in driving biodiversity. However, in alkali grasslands, precise soil levelling is essential for the elimination of landscape scars and restoring perennial grass cover.

## FLOWER POWER, THE BEETLES AND THE STONES: PROGRESS OF RESTORATION TRIALS AT THE DOUNREAY NUCLEAR PLANT, NORTHERN SCOTLAND

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Dounreay, on the north coast of Scotland, is the site of the United Kingdom's early research into fast breeder reactor technology. Developed from 1955, the site hosted three developmental reactors until it was closed in 1995. The site is being decommissioned and buildings are being demolished, with the scope that the site can be remediated and will host native vegetation once again. Where required, a 1-m high surface layer will be built up to help prevent contaminants from reaching biological receptors at the surface, where bioaccumulation of potentially harmful elements may occur. We used a fully factorial randomised block design to conduct a vegetation-rehabilitation trial at the Dounreay site. The objective was to identify what physical treatments (gravel size, with or without topsoil) and seed mixes (two types) would perform better for vegetation and invertebrate recovery. We installed pitfall traps in each treatment to estimate ground-dwelling invertebrate species numbers between treatments. Pitfall traps were collected bi-weekly, at the same time as vegetation surveys were conducted to evaluate plant species coverage across the treatments. We used inferential statistics to compare both invertebrates and plant species diversity and abundance between the treatments and correlate this with soil chemistry. Our preliminary results suggest that vegetation and invertebrates differed between treatments, with treatments including top soils showing more promise of a rapid vegetation recovery. The presentation will further discuss the results and the implications for the future of the site.

## POLLINATORS AT HUMAN-AFFECTED SITES: ROLE OF SUCCESSION

Dawid Moroń

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Pollinating insect populations, essential for maintaining wild plant diversity and agricultural productivity, rely on (semi)natural habitats. An increasing human population is encroaching upon and deteriorating pollinator habitats. Thus the population persistence of pollinating insects and their associated ecosystem services may depend upon human-affected sites; however, their importance for ecosystem services is barely understood. Thus, we tested whether railway embankments, levees or heavy metal polluted areas in southern Poland (overall 94 sites) establish habitats that support large populations of pollinators (bees, butterflies and hoverflies) when compared to typical habitats for these insects, i.e. semi-natural grasslands. We also examined whether vegetation succession, expressed as the density of shrubs and trees, is an important factor shaping pollinator population at these human-modified habitats. Species richness and abundance of pollinators were higher for railway embankments than for grasslands. Levees are equally good habitats for pollinators as control grasslands, whereas heavy metal polluted areas consist of a significantly lower number of species and individual pollinators compared to unpolluted sites. The vegetation succession modified the suitability of embankments, levees and polluted areas for pollinators. In all habitat types, succession negatively affected the number of pollinator species and their abundance. The study shows that at least some of the human-affected sites could constitute valuable habitats for the conservation of pollinators. Specific conservation strategies involving human-affected sites should focus on preventing habitat deterioration due to secondary succession.

# SESSION 16 – QUARRIES: WIN-WIN FOR BIODIVERSITY

**Chairs: Dido Gosse, Maxime Séleck**

Biodiversity in extractive sites is unique and its value is well recognized across all parties. Species and habitat management is needed and operations need to be well trained so that production can go hand in hand with nature protection. This session aims at exploring the contribution of the extractive sector to rare species and moreover the techniques and strategies to allow these species and habitats to colonize, expand and thrive. From these experiences and from actors having been working on nature conservation and restoration, we will also aim at presenting how the consideration of biodiversity objectives can lead to a Win-Win strategy.

SESSION 16-01 – QUARRIES: WIN-WIN FOR BIODIVERSITY

## 10 YEARS OF RELATIONS BETWEEN SCIENTISTS AND QUARRY OPERATORS: FROM CONSTRAINT COLLABORATIONS TO A REAL WIN-WIN PARTNERSHIP FOR BIODIVERSITY

Thierry Dutoit<sup>1</sup>, Pierre Bourguet<sup>2</sup>, Julie Chenot<sup>1</sup>, Elise Buisson<sup>1</sup>, Renaud Jaunatre<sup>3</sup>

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In the plain of La Crau (South-Eastern France), dry alluvial quarries are exploited since the 1970s, which has caused the destruction of more than 300 ha of the unique Mediterranean steppe of France. Relations established with quarry operators and scientists were developed at first under legal obligations to restore quarries after the end of exploitation. First results obtained since 2010 have shown that it was possible to use direct soil translocation for restoring the pre-existing steppe plant community (plant composition, species-richness); nevertheless, it was not possible to restore its whole integrity (plant diversity, structure, species turn-over, etc.). The use of this technique was also only possible when the pre-existing steppe vegetation and its soil had not been already destroyed. Then, since 2015, different complementary scientific experimentations have shown that new materials (substrate-soil mixtures) and processes could be proposed not only for increasing restoration success in the quarries but also to restore other degraded areas such as landfills, photovoltaic fields or even to create sustainable green roofs without irrigation in the Mediterranean area. Here we will present the first results of these different experimentations realized in partnership between quarry operators and scientists for the development of these new technologies at operational scales.

## QUARRIES MEET BIODIVERSITY: INSIGHTS FROM A LONG-TERM PROJECT OF QUARRY REHABILITATION

Carmo Silva<sup>1,2</sup>, Sofia Eufrazio<sup>1,2</sup>, Vânia Salgueiro<sup>1,2</sup>, Pedro Salgueiro<sup>1,2</sup>, Amália Oliveira<sup>2</sup>, Otilia Miralto<sup>2</sup>, Denis Medinas<sup>1,2</sup>, Alexandra Silva<sup>3</sup>, António Mira<sup>1,2</sup>

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The Outão rehabilitation plan for fauna is a 9-year project developed by the University of Évora and SECIL in a cement plant, aiming to minimize impacts from limestone quarries exploitation. This plan focuses on the availability of resources for fauna by managing food, water and shelter through the promotion of native fleshy-fruit plants, artificial ponds, rock piles or nest-boxes. The project extends the SECIL's quarry rehabilitation plan, on-going since 1982, where different techniques have been applied (soil reintroduction, hydroseeding, plantation of native vegetation) to recreate the naturally occurring Mediterranean sclerophyllous vegetation. A complete approach has been applied, integrating impact assessment, implementation of mitigation actions following an adaptive management strategy, and a monitoring program involving vertebrate (amphibians, reptiles, birds, mammals) and invertebrate (ground beetles, butterflies) sampling every 3 years. The project also accounts for pilot studies concerning the reestablishment of ecological processes. Fauna monitoring shows a convergence in species composition of rehabilitated areas and natural areas over the years (between 39–75% similarities). Increasing shelter availability significantly enhanced the abundance of tits ( $P < 0.002$ ) and small mammals ( $P = 0.005$ ), while increasing water availability increased local species richness in dryer months ( $R^2 = 0.59$ ,  $P < 0.001$ ). Pilot studies demonstrate that landscape connectivity for small mammals and mammal-mediated seed dispersal is sustained, revealing exchanges between rehabilitated and natural areas. We aim to provide guidelines for quarry rehabilitation practices enhancing wildlife and restoring ecological processes based on on-the-ground experience.

## OCCURRENCE RATES OF INVASIVE PLANTS IN LIMESTONE QUARRIES (SOUTHERN BELGIUM)

Carline Pitz, Alexis Jorion, Grégory Mahy, Arnaud Monty

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In quarries, invasive plant species can slow down the installation of high conservation value vegetation. Successful management of invasives requires, at first, a quantitative assessment of invasion levels. Although European legislation has adopted an ambitious strategy against invasive species, there is still a lack of knowledge about their occurrence in quarries. The aim of this study was to evaluate occurrence rates of invasive plant species in limestone quarries throughout Wallonia (southern Belgium) and identify high priority and emerging invasive plants for adapted management. During the 2016 vegetation period, 40 quarries were selected by stratified sampling, using abandoned and active quarries as strata. Within selected quarries, 2-m wide transects were established to cross all activity sectors. Transects were divided in 10 m x 2 m plots, resulting in 2% of total surface of each quarry being surveyed. Cover and number of individuals of invasive plants species were recorded in each plot. Species considered were those of the Harmonia list (67 species), the reference at the Wallonia scale; more than 30,000 plots were surveyed. Results of our recent study are presented (occurrences rates by species, mean percentage cover per site). First results indicate that dominant invasive species originate from different introduction paths: (i) planted (*Robinia pseudoacacia*); (ii) ornamentals (*Cotoneaster horizontalis*), and (iii) spontaneous colonization (*Senecio inaequidens*) – and follow various invasion dynamics. We propose research and management methods to be directed towards limitation of the top ten frequent species (e.g. *Buddleia davidii*, *Senecio inaequidens*), and to establish a detection system for emerging invasive plants.

## RELEASE OR RESTORE ABANDONED QUARRIES? THE CASE OF THE LA CRAU PLAIN IN SOUTH-EASTERN FRANCE

Julie Chenot<sup>1,2</sup>, Renaud Jaunatre<sup>3</sup>, Elise Buisson<sup>1</sup>, Thierry Dutoit<sup>1</sup>

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In the plain of La Crau (South-East of France), dry alluvial quarries were exploited in the 1970–1980s and are now mostly abandoned. They caused the destruction of more than 300 ha of a protected Mediterranean sub-steppe grassland. Currently, two options are available: a) trying to restore the former grassland so that it could hypothetically recover its initial state, or b) let novel ecosystems created by quarry abandonment have their own dynamics. Based on the establishment of an ecological diagnosis of quarry soil, flora, fauna and habitats, our objective is to provide keys to choose one of the options. For this, soil pits were dug and studied, floristic inventories were made, and amphibians, reptiles and birds species were identified. All this was realized both in quarries and in the reference steppe. The results show that some of the new ecosystems shelter high diversity, including some protected species. Nevertheless, 30 years after abandonment, none of the created habitat is similar to the sub-steppe even in quarries that benefited from rehabilitation by soil transfer. It therefore appears unnecessary to restore these quarries into the desired reference as it is impossible to cross the ecological irreversibility thresholds in the current state of scientific and technical knowledge; rather, their evolution should be followed over the long term. Indeed, restoration would lead to destruction of these novel ecosystems and their associated biodiversity. In conclusion, it is now more important to avoid further destruction of the steppe and if destroyed, to restore at best the destroyed areas by imitating spontaneous successional series identified during the diagnosis.

## DO WE NEED FORESTRY RECLAMATION OF SPOIL HEAPS IN THE CENTRAL EUROPE?

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Spontaneously revegetated (SR) and forestry reclaimed (FR) sites after brown coal mining were studied in three countries across central Europe. Representative sites varying in age (0.5–57 years) were sampled using phytosociological relevés (5 m x 5 m, SR = 53, FR = 56). All recorded species were classified using their affiliation to particular vegetation classes, life-history traits (life forms, diaspore characteristics) and habitat preferences. Multivariate and linear methods were used for data analyses. FR using a mixture of broadleaved native woody species did not differ from SR in species composition but in species traits. Reclamations formed by monocultures, especially of alien species, represented outliers with only few herb species with negligible cover. Grassland species were more abundant in SR, and their numbers increased in time while they decreased in FR. The number of species preferring semi-natural habitats was also higher in SR and increased in time while the number of cultural species (mostly ruderals and aliens) decreased. In FR, the representation of semi-natural species was lower and remained constant. Based on these findings, the minimum intervention approach is considered a more environment-friendly and cost-effective option for restoration of post-mining sites in central Europe. SR, in central European mining sites, goes towards at least similar but usually even more valuable outcomes as FR using a mixture of broadleaved native woody species, and should be given priority in places where there is no risk to public health and safety.

## TECHNICAL RECLAMATION CAN PRODUCE VALUABLE FRESHWATER HABITATS IN POSTMINING SITES: EXAMPLE OF THREATENED INSECTS IN LIGNITE SPOIL HEAPS

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Recently, it has been repeatedly documented that post-mining sites can offer crucial secondary surrogates for many highly threatened organisms. However, restoration practises crucially affect the conservation potential of such sites. The majority of studies revealed spontaneous or directed succession as a more efficient restoration tool than technical reclamation, in terms of nature conservation. On the other hand, all these studies focused solely on terrestrial biodiversity. We will summarise several years of our research of biodiversity of freshwater insects (dragonflies, true bugs, beetles) in lignite spoil heaps of various ages in the western Czech Republic. We studied technically reclaimed and spontaneously restored habitats of both stagnant and flowing waters. Besides community-wide studies (active searching for adult dragonflies, bait trapping of larger beetles, standardised sweeping of water beetles and other insect larvae), we focused on a population of the critically endangered damselfly *Coenagrion ornatum* in particular detail. Generally, by recording of numerous threatened species, we confirmed the unusually high conservation importance of such habitats. In contrast to studies of terrestrial habitats, the conservation value of technically reclaimed stagnant waters was comparable to spontaneously developed pools for the majority of the studied groups. In addition, reclamation created a dense network of channels occupied by rich communities of dragonflies including highly threatened specialists of headwaters. In conclusion, post-mining landscapes host freshwater habitats of high conservation value, even if technically reclaimed.

## LONG-TERM PLANNING FOR SUCCESSFUL BIODIVERSITY ENHANCEMENT AT BATTS COMBE QUARRY, SOMERSET, UK

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The Batts Combe Quarry site comprises a 60-ha carboniferous limestone quarry that has been operational for over 100 years within a total landholding of 180 ha in the Mendip Hills Area of Outstanding Natural Beauty (UK landscape and planning designation), set immediately adjacent to the tourist attraction of Cheddar Gorge and including 50 ha designated as a Site of Special Scientific Interest (UK biodiversity/geodiversity designation). There has been a long history of more than 35 years of research into quarry rehabilitation techniques, initially seeking to address issues of reducing visual impact of quarry faces close to residential areas, then moving towards biodiversity enhancement objectives. Decline in quality of adjacent semi-natural habitats has subsequently focussed attention beyond the operational areas, and in partnership with neighbouring landowners and NGOs there has been high quality habitat restoration and management under UK agri-environment schemes, achieving landscape-scale benefits and improved habitat linkage for key local species such as dormouse and bats. The presentation and case study will show the trends and history over many years of developing best practice and innovative techniques in quarry reclamation and management of the Company's surrounding land.

## THE LIFE IN QUARRIES PROJECT: BUILDING PARTNERS' CONFIDENCE AND SOUND NATURE MANAGEMENT WITHIN ACTIVE QUARRIES

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Throughout the life of quarries, a large diversity of temporary habitats is generated, sometimes left to evolve to more permanent ones. In urbanized and controlled landscapes, quarries are an exceptional opportunity to maintain rare and threatened transient habitats hosting fugitive species. Such ephemeral biodiversity cannot be managed through a site legal protection status. While the extractive industry is willing to understand and manage sites' biodiversity, lack of knowledge on the true biodiversity potential can jeopardize fugitive biodiversity installation successes and prevents an optimal restoration of ecosystem services in the postexploitation phase. A partnership build between FEDIEX, coordinating the project for Walloon quarries, University of Liège, Natagora (NGO) and Plaines de l'Escaut Nature Park allows the private and public sector to work hand in hand in the LIFE In Quarries (LIFE14 NAT/BE/000364) in order to: (i) test and define methods for the management of fugitive species and pioneer habitats; (ii) prepare the physical quarry infrastructure in order to facilitate the establishment of restoration plans; (iii) identify situations preventing the adoption of explicit new management measures; (iv) develop the awareness of a diversity of stakeholders; and (v) disseminate good practices at a EU scale. After a few months of project, we will report on the difficulties encountered in and solutions for meeting the interest of stakeholders originating from contrasting backgrounds, as well as on encountered lock-in situations and opportunities that can limit or facilitate the implementation of fruitful temporary nature actions within industrial sites. Perspectives from the project actors will be developed.

## RESTORATION THROUGH PARTNERSHIPS: LESSONS LEARNED FROM INDUSTRY AND NGO CASE STUDIES

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Partnerships among companies in the extractive industry and NGOs or academic institutes have become part of the mainstream in natural resource conservation at mineral extraction sites. These partnerships are driven by collaborative opportunities to promote nature protection; to minimise business risk; and to improve relationships with local stakeholders. From the industry side, this pro-active approach is fundamental to local public support and in securing our licence to operate, while collaboration truly increases the value of biodiversity and rehabilitation projects. Drawing experience from existing partnerships, we take stock of the achievements and lessons learned and share perspectives on the potential for further development of business-NGO partnerships in line with the international ecological restoration agenda.



## THE ROLE OF EARLY-SUCCESSIONAL STAGES AT MINING SITES FOR THE CONSERVATION OF ENDANGERED AMPHIBIANS AND BREEDING BIRDS IN GERMANY

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A large number of pioneer species are endangered in Central Europe by habitat loss. Due to mining, quarries provide important secondary habitats for these species and play a vital role for their conservation, especially for amphibians and breeding birds. Even though areas suitable for pioneer species are quickly transformed by natural vegetation development, the mining process continuously re-creates such favourable conditions, allowing for stable populations over long periods of time. Examples of species benefitting from the provision of suitable habitats within quarries are Little Ringed Plover, which breed on exposed gravel plains, or Sand Martins, which dig their nests in steep sandy slopes. Amongst the amphibians, Yellow-bellied Toads spawn e.g. in tracks of trucks, and Green or Natterjack Toads occupy flat, temporary wetlands. Away from the immediate mining zone, natural re-vegetation leads to a highly structured landscape and a diverse species community, as the species composition changes over time from those characteristic of open areas to those of transitional habitats such as scrub. Finally, typical forest birds will occupy the abandoned quarry. To protect endangered species and to harmonize mining activities with their ecological requirements and to save costs, Heidelberg Cement has developed different projects and management programs in cooperation with e.g. BirdLife in its quarries.

## QUARRIES AS HABITATS FOR CLIFF-NESTING BIRD SPECIES

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Birds are one of the main targets in mining rehabilitation. It is known that cliff-nesting bird species colonize human-created environments such as quarries and that their natural habitats are disappearing. Some bird species in central Spain, such as the Sand Martins (*Riparia riparia*), have very high proportions of their populations linked to extractive areas. However, previous work has often failed to address how important these artificial areas are for the conservation of rupicolous birds and how to promote their presence. Nine quarries were censused for rupicolous birds during breeding season in central Spain, and factors related to habitat selection of these species were studied across several spatial scales (nest, cliff, quarry & landscape). We censused 19 rupicolous species, among which the major types of birds present were different species of sparrows, swallows and corvids. Some quarries had remarkable species richness (14 rupicolous species), including species that are endangered at a national level. We censused approximately 6,500 individuals, and found populations which exceeded 1,000 individuals in a single quarry. Different species selected different cliffs and stockpiles according to their morphology. The eagle owl colonized the quarries frequently (78% of the quarries). Our results show that industrial habitats created through quarrying offer opportunities to enhance rupicolous birds. Managing quarries could be an opportunity to recreate a scarce habitat and to improve local biodiversity. However, projects to improve the habitat for rupicolous birds in central Spain should take into account the possible presence of the eagle owl, so as to avoid creating ecological traps due to its high predation on other rupicolous birds.

## ECOLOGICAL SUCCESSION IN THE POST-MINING AREAS: THE SITNO GRAVEL PIT CASE STUDY

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Activities have been dedicated to support the reclamation of gravel pit lakes in Sitno (northern part of Mazovia region, Central Poland) in order to optimize their impact on biodiversity and to develop the best practice for similar sites. After modification by traditional reclamation (shaping the water reservoirs edge for low-angle slopes and diverse shore line, planting native plant species dedicated to habitats), aimed at creating suitable habitats for selected vertebrate and invertebrate fauna groups and at minimizing negative impact on the surrounding habitats, an effectiveness assessment was conducted, based on succession monitoring and focusing on fauna of amphibians and some groups of invertebrates (dragonflies). The inventory consisted of identification of species composition and plant succession analysis. Species occurrence in relation to habitat preferences of the most valuable and vulnerable species, selected as sensitive bioindicators of habitat changes, proved the usefulness of the adopted solutions. Colonisation rate was high, which made it possible to conclude on best practices for reclamation of gravel pit lakes in the conditions of Central Poland.

## ANALYSIS OF FOREST ECOSYSTEM RESTORATION ON POST-MINE OIL SHALE QUARRIES

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Opencast mining affects landscape, common land use and natural balance, and it is a serious environmental issue all over the world. A mining area might be relatively small on a world scale considering the land area and environmental effects, but its effects are much larger locally and regionally. Forest plantations can play a key role in harmonizing long-term rehabilitation of the ecosystem in restoring productivity, biological diversity and integrity on areas degraded by mining. The selection of exotic or native species needs careful consideration, because it may be necessary to use species combinations (native, exotic or combination thereof) that are capable of surviving in newly created conditions. The study was carried out on three post-mine oil shale quarries in northeast of Estonia in the hemiboreal vegetation zone in 2012. The experimental area with 140 plots of different tree species is established since 1968. The study includes a complex monitoring of forest stands, ground vegetation and soil. The preliminary results are: soil thickness and stoniness influence tree growth; new suitable habitat is forming for threatened herbaceous species; the afforestation process is developing differently in three quarries.

## ONE MORE STEP TOWARDS BIODIVERSITY – NO LITTLE MEASURE IS TOO LITTLE IN RESTORATION PROJECTS

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Mining companies are obliged to restore quarries and pits after extraction. The easiest way is usually to apply standard methods, the modern way is to count on natural succession. However, not always are these techniques the best and sometimes their use is not possible. Nowadays, smart restoration is the goal of the modern miner. The sight from out of the box can bring solutions which do not increase costs for the company but which enhance nature value of mined or restored sites and involve local partners. Best practise case studies from the Czech Republic will be introduced, for example simple beneficial changes in sand pit restoration procedures, views on multifunctional use of spoil heaps or bank stabilizations. The presentation will show: Genesis of ideas; the needs of company, environment and local stakeholders; how to win project partners; project time schedules, budgets and results.

## CAN QUARRIES PROVIDE NOVEL HABITAT CONDITIONS FOR A ROCKY BIRD SPECIES? THE BLACK REDSTART (*PHOENICURUS OCHRUIROS*) AS A CASE STUDY

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Quarries are often considered ecologically degraded sites of low interest for biodiversity conservation. However, the quarry landform can provide unique suitable artificial conditions for rocky species to colonize. This study aims to evaluate if the existence of quarries promotes Black redstart (*Phoenicurus ochruros*) occurrence in a typically non-suitable landscape. Our results intend to explore other views of quarry rehabilitation that can complement classic approaches. The study took place in western Portugal on two SECIL cement plants. We studied 21 transects in six quarries and adjacent areas between January and June 2012, mapping Black redstart's territories through the location of male observations. We evaluated territory placement, taking in consideration five variables: mean slope, forest and quarry percentage cover, number of habitats and built-up area. Data was analysed with Generalized Linear Models, following the Information Theoretic Approach. A total of 25 Black redstarts' territories were identified in quarries (n = 13), urban (n = 11) and forest areas (n = 1). Results showed that Black redstarts select quarries to place their territories especially when their presence is constrained by unsuitable surrounding forest habitats. Quarries can endow landscapes with novel elements, e.g. steep slopes, which benefits Black redstarts' occurrence. These novel elements can be taken into account when planning rehabilitation practices, both for specific conservation goals or to enhance local biodiversity.

## SUCCESSION OF AQUATIC AND WETLAND VEGETATION IN ABANDONED SAND PITS

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The study was conducted in Třeboň region, Czech Republic, where there are numerous residual lakes in sand pits in which succession starts after cease of sand and gravel extraction. Successional vegetation obviously contributes to the aquatic and wetland diversity in the region. Aquatic and wetland species were surveyed during the summer 2015 together with some site environmental parameters, namely position of water table and substratum texture. This preliminary study was conducted in six sand pits ranging in age from 0.5 to 30 years since abandonment. Altogether 27 vegetation samples with 16 m<sup>2</sup> area were recorded with species cover visually estimated. The data were elaborated by Detrended Correspondence Analysis and Canonical Correspondence Analysis in the Canoco<sub>5</sub> program. Altogether 97 species of vascular plants were recorded, including eleven species of the Red List of vascular plants of the Czech Republic. Ordination analyses showed that soil type ( $p = 0.018$ ) as well as age since the abandonment ( $p = 0.002$ ) had significant effect on the vegetation composition. This preliminary study showed that further research on the aquatic and wetland succession in abandoned sand pits is desirable. Results can be used in restoration projects to find ecologically wise approaches.

# SESSION 17 – MAKING RESTORATION ECONOMICALLY SUSTAINABLE

**Chairs: Thomas Knoke, Nick Hanley**

Humans have shaped the world's landscapes in response to economic opportunities. On the global scale this has led to a conversion of more than 50% of our original ecosystems towards anthropogenic replacement systems. Restoration of large parts of these anthropogenic ecosystems, trying to bring back the initial ecosystem structures, their biodiversity and services, will often pose a conflict with the economic opportunities. In light of this situation, it will be crucial to quantify trade-offs and to offer solutions for their minimization, or to even develop win-win solutions. Scientific but also pragmatic solutions are urgently needed to reconcile restoration initiatives with people's economic requirements. Key questions of the session include: How can the comprehensive consequences of restoration concepts and initiatives be quantified for a broad range of ecosystem services? How can approaches be aggregated from the plot to the landscape scale? How can trade-offs between multiple ecosystems services be minimized? What is the role of uncertainty? How can socio-economic data support bio-economic models? We welcome, inter alia, empirical, comparative and theoretical studies as well as all kinds of socio-economic/bio-economic modelling approaches.

SESSION 17-01 – MAKING RESTORATION ECONOMICALLY SUSTAINABLE

## ALTERNATIVE ECOSYSTEM REGIMES AS A GUIDE TO ECONOMICALLY SUSTAINABLE RESTORATION

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Degraded land cannot be easily restored everywhere at acceptable cost. Thus, decisions are required on where and when best to invest in restoration. Particularly, the presence of alternative ecosystem regimes matters greatly for financial viability of investments, as does the opening of an ecological window of opportunity (e.g. very wet period). Here, we present a decision-support tool based on dynamic ecosystem regimes to guide economically sustainable restoration. It explicitly considers degradation severity, hysteresis thresholds and suitable management timings. Applying this tool to Mediterranean rangelands, we assess discounted investment and maintenance costs as well as benefits (e.g. pasture productivity and cover) dependent on stability domains and windows of opportunities. Results demonstrate greater chance of success and higher returns on investment in a bi-stable domain when interventions (e.g. seeding, manuring) coincide with a climate window of opportunity. When investments are insufficient for an ecosystem to cross a threshold, costs to maintain the achieved improvement are incurred while waiting for a new window of opportunity. Our decision-support tool is widely applicable and enables the development of generic restoration principles. It provides a new way of analysing costs and benefits of action and inaction, allowing land managers to focus their restoration and monitoring efforts on situations for which they are likely to have the greatest effect.

## AGROFORESTRY FOR PROMOTING PRODUCTIVE FOREST RESTORATION IN THE TROPICS

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The increasing demand for food, energy and materials poses a severe conflict with the objective of restoring natural ecosystems. To mitigate this conflict, traditional land-use practices such as agroforestry are being revisited for reconciling productive and protective functions. Agroforestry is often regarded as a way to integrate single trees into agricultural landscapes. The potential of integrating an agricultural component in reforestation for initiating large-scale forest restoration has, however, often been disregarded. By presenting results from a field trial in Panama, we show that combining tree seedlings with staple food crops can reduce major drawbacks to the reforestation of degraded tropical pastures: Planting food crops during the first years of tree development can generate early returns and hence mitigate major obstacles to reforestation, namely the high upfront investment and the delayed revenues from wood harvests. The trial furthermore indicates facilitation effects of crops on trees and an improved survival of tree seedlings. By coupling biophysical and economic data we furthermore demonstrate the advantage of product diversification for reducing financial risks of reforestation. Tree-based agroforestry thus offers an important tool to reconcile ecological restoration with economic needs in rural areas. We conclude by discussing potential agro-successional pathways for productive restoration on a landscape level.

## BALANCING COSTS AND NATURE VALUES IN PRIORITIZATION SCHEMES – EXAMPLES FROM THE FINNISH RESTORATION PRIORITIZATION PLAN

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<sup>3</sup>*University of Helsinki, Department of Biosciences, FI*

This contribution highlights the key messages from the Finnish restoration prioritization plan on the options and costs of restoring 15% of degraded ecosystems following the CBD Aichi target. We present a procedure that enables us i) to systematically estimate the magnitude of degradation from which the 15% can be calculated, ii) to evaluate the magnitude of improvement different restoration measures can offer, and iii) to prioritize restoration measures within and between ecosystem types. First, we will show that from an ecological perspective, it is necessary to recognize that ecosystem degradation has a minimum of two components: the extent of area that has become degraded and the magnitude of the degradation at any given location. Second, we will present Finnish examples of prioritization of cost-efficient restoration measures across ecosystems. The examples emphasize that prioritization within and between ecosystems deliver significant economic benefits. If we focus on restoring 15% of one ecosystem type at the time, the overall cost of meeting the 15% restoration target is more than twice compared to the prioritization approach we present here. Finally, we will conclude by presenting alternative targets for restoration and, based on results from Finland, discuss the future steps needed in order to effectively plan and implement work towards meeting the global target of restoring 15% of degraded ecosystems.

## TARGETING RESTORATION THROUGH SPATIAL CONSERVATION PRIORITIZATION

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Achieving the global 15% restoration target is a huge task. Avoiding harmful opportunism, while recognizing beneficial opportunities, is challenging our current operational practices for cost-effective conservation resource allocation. Here I will present two examples of how cost-effective restoration considerations can be supported in conservation decision-making processes. The first example illustrates how considering restoration need and costs is incorporated into a large-scale spatial prioritization analysis for the expansion of a protected area network for mires in Finland. Here, the restoration need and costs for the candidate sites are added to the prioritization equation as an additional element on top of the biodiversity value of the sites, thus balancing the needs to protect and to restore. The second example is a step further where a large part of a national scale conservation area network – protected Natura2000 areas in Finland – are prioritized from the perspective of finding areas in which to focus the resources for restoration and management. In this analysis, we spatially apply habitat specific data on restoration effects and costs determined by over 100 experts involved in the work of the Finnish restoration prioritization working group. Together, these examples demonstrate a systematic planning approach of taking cost-effective steps towards the 15% target.

# SESSION 18 – SOIL RESTORATION USING ORGANIC AMENDMENTS

**Chairs: Deborah Page-Dumroese, Nathaniel Anderson, Viktor Bruckman**

This session will address issues of using biochar and recycling soil organic matter to help restore degraded forest, range, or mine soils. We will discuss harvest operations, pyrolysis, life cycle analyses, and soil response to organic amendments. We will address the issues of best management practices for restoration across a variety of ecosystems and also ecosystem services and costs associated with soil restoration using organic amendments. Our speakers will discuss how to efficiently move waste forest woody residues, how to value these “traditional” waste products, conversion using pyrolysis, other sources of organic amendments, and the impacts of these amendments on aboveground production. Our approach will be a complete analysis of woody residue supplies, movement along the supply chain, and ultimately how amendments impact vegetation growth or soil processes. This session is relevant for numerous entities seeking to use organic amendments to restore soil function and quality.

## URBAN TREE DEBRIS AS ORGANIC MULCH: EFFECTS ON SOIL CHARACTERISTICS AND TREE GROWTH

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Post-hurricane ecological restoration of urban forests in Louisiana, USA is a challenging task. In recent years, hurricanes in Louisiana have generated a significant amount of vegetative debris, consisting of whole trees, tree stumps, tree branches, tree trunks, and leafy material. Utilization of urban tree-based waste as mulch may assist the recovery of resilience and adaptive capacity of the urban forest ecosystems that have been degraded or damaged by hurricanes. The goal of this study was to assess the contribution of tree-based waste as mulch to urban forest soil and urban tree growth. The specific objectives were to (1) quantify the effects on urban soil respiration, (2) evaluate soil moisture, temperature, and pH level, (3) examine the net photosynthesis of newly planted *Quercus nuttallii*, and (4) assess the impact of mulch types on shoot elongation. Five types of tree-debris based mulches – Mixed Hardwood, Mixed Oaks, Pine Wood+Bark, Pine Needle+Bark – were used in a completely randomized block design experiment. Soil respiration data were collected with a LI-COR Automated Soil CO<sub>2</sub> Flux System. Soil temperature and moisture were recorded with the soil temperature and moisture probes. Net photosynthesis data of *Q. nuttallii* saplings were collected with the LI-COR 6400 portable photosynthesis system. Shoot growth was recorded periodically. Results indicated that tree-based mulch significantly increased soil respiration, soil temperature, soil moisture, tree net photosynthesis, and shoot elongation. The use of hurricane generated tree-based wood wastes as mulch could have significant positive impacts on the restoration of degraded or damaged urban forest ecosystems.



## THE SUPPLY CHAIN OF BIOCHAR: ASPECTS FOR SOIL RESTORATION

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Biochar, the solid residue of heating biomass in an oxygen-limited environment, is recently gaining attention as a promising tool for environmental management, including soil restoration. It has become one of the key issues in soil research in the last few years. Since a potential biochar system has many variables from feedstock reactor type and settings to application details, a nearly indefinite number of system permutations exist. Hence it is challenging to provide scientifically sound answers to questions that arise when using biochar in the field. This presentation will focus on the biochar supply chain and introduce different types of theoretical biochar systems with a strong focus on forestry. The second part of the presentation will present actual examples, where biochar is used for reforestation of degraded or contaminated sites, for nutrient and water retention or for sequestering carbon in forest soils. The examples presented are of interest for science and practitioners alike, as these are further represented in a government report about biochar use in agriculture and forestry which is currently in preparation in Austria.

## HOW TO EVALUATE THE SUITABILITY OF ORGANIC AMENDMENTS FOR SOIL LAND-SPREADING IN RELATION TO LEGISLATION AND SOIL PROPERTIES?

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Organic amendments re-use on soil is a site- and waste-specific issue and therefore, prior to landspreading, a series of studies and analyses should be performed in order to assess (1) land suitability, considering hydrological and geomorphological characteristics, (2) waste composition and characteristics, (3) restrictions of the current legislative framework, and (4) soil quality. As has been proven in the framework of two LIFE projects, namely “AgroStrat” and “PROSODOL”, different types of organic residues affect soil properties in different ways. Therefore, prior to re-use, the specific soil properties anticipated to be affected should be defined, and their values must be considered when estimating annual waste doses in order to ensure positive impacts on soil quality and on the general environmental status of the area. The estimation of the annual waste amounts in relation to soil properties and legislative restrictions are presented in this study, considering two types of organic residues, i.e. olive mill wastes (OMW) and pistachio wastes. Both of them have been applied in two pilot areas in Greece. These two waste types are typical for the Mediterranean area; they contain phytotoxic substances (e.g. polyphenols), and OMW is considered as one of the most significant problems in the Mediterranean due to the huge amounts produced and disposed annually. Due to the very high content in organic matter and in minerals, both waste types could be used for the restoration of soils poor in organic matter and in nutrients, of soils degraded due to intensified agriculture as well as for the enrichment and protection of Mediterranean soils against desertification.

## CHANGES IN DECOMPOSITION RATES AFTER FOREST THINNING AND APPLICATION OF SOIL AMENDMENTS

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Waste wood created during biomass thinnings can be used for bioenergy and to create biochar and subsequently apply it to compacted soil or those lacking organic matter. In western Montana, we conducted a field study using the following treatments replicated 3 times: (1) 22 Mg/ha biochar; (2) 22 Mg/ha biochar with 224 kg/ha N fertilizer; (3) 224 kg/ha N fertilizer only; (5) 22 Mg/ha retained fresh biomass, and (6) a control. Amendments were applied in a 14' radius around individual trees of uniform height, diameter, and health. After applying the amendments, we installed standard pine and aspen wood stakes (2.5 cm x 2.5 cm x 20 cm) in the mineral soil, on the soil surface, and at the mineral soil/forest floor interface to assess decomposition rates. Aspen and pine decomposition rates increased under the fertilization treatment. Both species of stakes at the mineral soil/forest floor interface were generally more decomposed than stakes on the soil surface.

## BIOCHAR AMENDMENT, FERTILIZATION, AND MASTICATION IMPACTS ON PONDEROSA PINE TREE GROWTH

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Management and restoration practices in even-age ponderosa pine (*Pinus ponderosa*) stands in the Intermountain West (USA) can be improved upon by developing a more thorough understanding of the effects of biomass mastication, biochar addition and fertilization on tree growth and soil properties. Biochar is recommended as a soil amendment for a number of reasons including increasing water holding capacity, nutrient retention, and building soil aggregates but its effects on temperate forest soils and ponderosa pine growth alone, and with fertilizer and biomass treatments, are largely unevaluated. To determine these treatment effects on tree growth and soil properties we installed a study of seven soil treatments replicated 6 times. Study trees were measured in June 2010 and re-measured in June 2012 and August 2015. The treatments are control (removal of the overstory, biomass left), retained masticated wood chips (22 Mg/ha rate), fertilizer (224 kg/ha N), low-density biochar addition (2.75 kg/ha), high-density biochar addition (22 kg/ha tons/acre), low-density biochar addition with fertilizer (2.75 tons/acre and 224 kg/ha N) and high-density biochar addition with fertilizer (22 kg/ha and 224 kg/ha N). Tree growth after five years in the high biochar plus fertilization was 369% greater than control trees. Tree DBH after 2 and 5 years in the high biochar plus fertilizer was 35% and 41% greater than the control trees, respectively. On dry sites in western Montana, biochar provides long-term carbon sequestration and may help mitigate drought conditions thereby increasing tree growth and vigor.

# SESSION 19 – RESTORING BIODIVERSITY ON ARABLE LAND

**Chair: Harald Albrecht**

Arable land provides important ecosystem services, including biodiversity in the cultural landscape and the production of raw materials. During the last decades, increasing intensification, however, has led to a severe decline of agrobiodiversity. With fundamental importance for production, arable fields particularly suffered from this development. Facing this strong decline of arable biodiversity scientists and conservationists in various countries have recently started to develop research and management programs.

The aim of this session is to provide a platform for international exchange of corresponding ideas and experiences from different regions. We particularly want to focus on specific measures and research activities on management of rare species and their habitats, and on restoration measures like the re-establishment of populations of threatened arable plants. Furthermore, we welcome studies on biodiversity management of pollinating insects, birds and other organism groups with a high nature conservation value.

SESSION 19-01 – RESTORING BIODIVERSITY ON ARABLE LAND

## ARABLE PLANT CONSERVATION IN GERMANY – PRACTICAL KNOWLEDGE AND MANAGEMENT GUIDELINES

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One of the most strongly modified habitats is arable land, which was home to diverse communities of plants and their associated fauna adapted to the management regimes. A recent re-sampling study demonstrated a vast extent of changes over 50–60 years, with plot-level richness declining by >70%, while arable plant cover declined by >90%. Nowadays, in particular, the lack of diagnostic taxa makes it impossible to assign recent vegetation samples to established phytosociological associations or alliances. Besides existing protection measures (e.g. field margin programs), the restoration of phytodiversity is one crucial activity in agroecosystem conservation. Within the project “100 Fields for Diversity”, 112 important arable plant areas (IAPA) with a total area of ~470 ha were secured for at least 10 ys (often up to 20–25 ys) by contracts and appropriate agricultural practices. The fields are distributed over the whole area of Germany, on either limestone, sandy or loamy soils, with arable communities harbouring many rare and diagnostic species. A key element is the commitment to extensive farming practices targeted at promoting endangered species. Strict management prescriptions should not be set in the beginning; rather, experimenting with and refining measures has proved to be more successful in achieving the project goals. To assist such preservation efforts, a bibliography with more than 1,700 cited records of conservation measures for arable plants and their habitats was published.

## CHARACTERISTIC ARABLE WEED SPECIES IN NE SPAIN: WHAT CAN WE DO TO CONSERVE THEM?

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Among the weed species thriving in arable fields, those species characteristic of these habitats have suffered most from agricultural intensification, and their populations have been drastically reduced. These species have a higher conservation value in farming systems because they are specific of arable communities and confer them a special identity. However, little is known about the real impact of agricultural intensification on characteristic arable species and about the processes that made them rare. This lack of knowledge prevents the proposal of conservation strategies. We examined characteristic species of winter cereal fields in 304 organically managed fields in 2011, and analysed their presence and frequency in relation to farming practices and landscape structure using multimodel inference. Besides, we assessed the effects that particular farming practices (herbicide application and fertilization) have on eight weeds, and determined whether these practices may have contributed to their rarity by comparing the functional responses of common and rare species through non-linear models. We found 65 characteristic weeds, 46 of which are rare in Catalonia. Autumn-sowing of cereal crop varieties, non-inversion tillage and the adjustment of fertilization promote their presence, whereas ryegrass sowing, slurry application, high crop cover jointly with high fertilisation and grazing have the most negative effects. Experimentally, the pressure from herbicides and mineral fertilisation in interaction with crop affected the arable species negatively, with significant differences between common and rare species. But the reason for the rarity of certain species lies beyond these practices, the effects of which are highly species dependent.

## SOWING SEEDS OF RARE ARABLE WEEDS ON CROP EDGES: A DOUBLE OPPORTUNITY TO RESTORE BIODIVERSITY IN ARABLE FIELDS AND TO PRESERVE ENDANGERED PLANTS

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Arable plant communities are now among the most threatened ones and many weed species limited to arable fields are on the brink of extinction in European countries. Sowing seeds of rare arable weeds might be an opportunity both to preserve threatened plants adapted to arable habitats and to contribute to farmland biodiversity providing valuable ecosystem services like pollination. It is required to have seeds available and to make sure that the cover is effective to host biodiversity. The first steps of seed production have been initiated in the Midi-Pyrénées region for eleven species: seeds of rare arable weeds were collected in local crops and multiplied by a producer of organic seeds. These productions will comply with the quality trademark "Vraies messicoles", a national system for certification of wild seeds of native plant species set up by the Federation of the National Botanic Conservatoires. The local hunter's Federation and its partners implemented an experiment to compare biodiversity in uncropped field margins sown with ornamental spring flowers or with rare arable weeds, mixed with cereals or not, in two different sites. Wild flora and arthropods were mainly investigated. The results, obtained by analysing the content of 6 traps in each experimental implantation, show the value of arable weed covers to host arthropods, especially Carabids, including several species of insects beneficial to crops. Floristic diversity is higher in bands where wild species were sown and the development of invasive weeds is limited. The influence of soil preparation and implantation season will be discussed.

## RE-INTRODUCTION OF RARE ARABLE PLANTS ON ORGANIC FARMS: ESTABLISHMENT AND IMPACT ON CROP YIELD

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The diversity of arable plants has markedly declined during the past decades and many species are threatened in European countries. Organic farms are important retreats for these species, but spontaneous re-establishment on suitable habitats is not likely. Thus, re-introduction of endangered species by seed transfer has to be used to restore agrobiodiversity. Establishment of three winter annuals (*Legousia speculum-veneris*, *Consolida regalis*, *Lithospermum arvense*), their dispersal from sown plots, and potential impact on crop yield were measured on four organic farms near Munich, Germany. In autumn 2011, a mixture of the study species (850 seeds m<sup>-2</sup>) was sown on each site in a one-factorial block design with four replications (plot size 25 m<sup>2</sup>). In the first year, all study species could be found in winter cereals at all sites, and their seed production mostly exceeded initial sowing density. After three years, establishment of *L. speculum-veneris* was still high, *C. regalis* could be found at least in the soil seed bank, but not *L. arvense*. Establishment varied according to crop rotations and decreased especially under soy bean. Dispersal distance was >15 m for *L. speculum-veneris*, <13 m for *C. regalis* and <11 m for *L. arvense*. Crop yield was not reduced significantly in all study years and sites. We conclude that successful re-introduction of rare arable plants can be integrated in organic crop production.

The project was funded by the Federal Ministry of Food and Agriculture (BÖLN 06OE355, 06OE356).

## SEED PREFERENCES BY RODENTS IN ARABLE LANDSCAPES AND IMPLICATIONS FOR AGROECOLOGICAL RESTORATION APPROACHES

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Post-dispersal seed predation and endozoochory seed dispersal are two antagonistic processes in relation to plant recruitment, but rely on similar preconditions such as feeding behaviour of seed consumers and seed traits. In agricultural landscapes rodents are important seed predators, thereby potentially providing regulating ecosystem services in terms of biological weed control. However, their potential to disperse seeds endozoochorously is largely unknown. We exposed seeds of arable plant species with different seed traits (seed weight, nutrient content) and different red list status in a rye stand and assessed seed removal by rodents. In a complementary laboratory experiment consumption rates, feeding preferences and potential endozoochory by two vole species (*Microtus arvalis* and *Myodes glareolus*) were tested. Seed consumption by rodents after 24 h was 35% in the field and 90% in the laboratory. Both vole species preferred nutrient-rich over nutrient-poor seeds and *M. glareolus* further preferred light over heavy seeds and seeds of common over those of endangered plants. Endozoochory by voles could be neglected for all tested plant species, as no seeds germinated from faeces. Our results imply that voles can provide regulating services in agricultural landscapes by depleting the seed shadow of common weeds, rather than facilitating plant recruitment by endozoochory. Endangered arable plants were less preferred by voles than noxious weeds, and thus, our results provide implications for seed choice in restoration approaches.

## REDUCING FIELD SIZE AND FARMING INTENSITY TO ENHANCE ARABLE FIELD CENTRES AS SUITABLE HABITATS FOR BIRDS AND SMALL MAMMALS

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Local management intensification and landscape simplification contribute to the decline of many taxa of arable habitats, such as birds and small mammals. To restore biodiversity in arable land, local measures targeting extensive field management and increase in landscape heterogeneity are important. We studied birds, nest predation and small mammals in pairs of extensively (organic) and intensively (conventional) used winter wheat fields within landscapes of small field sizes (west Germany) and large field sizes (east Germany). Abundance and species richness were assessed at field edges and centres, where four artificial ground nests per transect baited with one quail and one plasticine egg each were exposed. We found no significant single effects of farming intensity or landscape structure on abundance or species richness of both groups, but nest predation was higher in organic fields. In intensively and extensively used fields, except for small extensively used fields, there was a decrease in bird abundance and richness and small mammal richness from field edge to centre. An exception was found for skylarks, which were more abundant in field centres, coupled with a reduced nest predation rate. The study reveals landscape-dependent effectiveness of extensification measures for arable fields. Reduction of field size in combination with extensive farming might be an appropriate restoration measure enhancing the ecological value of arable field centres.

## PROMOTION OF RARE ARABLE PLANT SPECIES BY SEED TRANSFER – A BENEFIT FOR CULTURAL LANDSCAPES IN BAVARIA

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Arable plants play an important role in functional biodiversity of agro-ecosystems and have characterized the cultural landscapes of Europe for millennia. However, due to agricultural intensification, the arable flora is considered to be currently one of the most threatened plant groups on this continent. Our four-year project aims to promote rare arable plant species within five natural regions covering large parts of Bavaria, Germany. This is done by collecting seeds of Red List species, propagating them with farmers and botanical gardens and re-introducing them to extensively managed fields. Therefore, we defined several key regions where remaining arable plant populations need to be enhanced. Study species were chosen depending on the site conditions, e.g. *Bupleurum rotundifolium* for calcareous soils, *Arnoseris minima* for sandy, acid soils, and *Myosurus minimus* for alternately wet soils. We present a two-step concept for the re-introduction of attractive flagship species on the one hand and of severely threatened species on the other hand. Furthermore, our strategy of building up value chains for the propagation or rare arable plants is demonstrated. The project is funded by the Bavarian Nature Conservation Fund and the Landwirtschaftliche Rentenbank.

## ESTABLISHMENT OF PERENNIAL FIELD MARGINS AND THE DEVELOPMENT OF SITE-ADAPTED SEED MIXTURES

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In many European countries species-rich perennial field margins and other uncropped areas in agricultural landscapes have been lost or degraded due to land-use intensification. In Lower Saxony (Northern Germany), current agri-environmental schemes (AES) include a program on restoring perennial flower strips by seeding a prescribed seed mixture with native wildflowers of regional provenance and some short-lived crop species. In 2015, we started field experiments (block design) to test different seed mixtures (prescribed AES mixture + additional mixtures) and management variants (e.g. mulching in September or March). In addition, we carry out a monitoring on fields of local farmers in Lower Saxony, who take part in the AES program in order to evaluate effects of different environmental conditions on vegetation structure, species composition and flowering aspect. In general, all treatments led to structurally diverse vegetation with a distinct flowering aspect. At the different study sites 75% to 100% of the sown species established successfully in the first year. Different mulching regimes showed only few differences during the first vegetation period. Large differences in vegetation development between and within study sites, however, indicate strong effects of varying soil conditions and shading. This means that a careful selection of species for different environmental conditions is necessary for a successful establishment of perennial field margin strips. The monitoring will be continued in 2016 and further results will be presented.

## BIODIVERSITY OF ARABLE AND EX-ARABLE LAND IN WESTERN SIBERIA - IMPLICATIONS FOR ECOSYSTEM RESTORATION

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In the Western Siberian grain belt, large areas of arable land have been abandoned after the breakdown of the Soviet Union. We studied plant and grasshopper diversity on arable and ex-arable land in the temperate forest steppe zone of Tyumen region using a randomized sampling design in three test areas of 20 km x 20 km. Weed vegetation of arable land was generally species poor and most of the species were common throughout the temperate zone. In contrast, succession on ex-arable land led to the recovery of species-rich grassland vegetation providing habitats for many typical ancient grassland species. Although total plant species richness was higher on ex-arable land than in ancient grassland, several meadow steppe species were still missing due to dispersal limitation. Orthoptera diversity and species composition on ex-arable land was significantly higher on ex-arable fields than on arable land and similar to ancient grasslands indicating complete recovery of grasshopper communities. Interestingly, grasshoppers used arable land for reproduction, but grasshopper species richness and densities were lower than in ancient grassland. In summary, our results show that the collapse of the Soviet Union has resulted in the establishment of ex-arable grasslands of high conservation value, while the phytodiversity of arable land is restricted by a small species pool due to the short history of arable land use and climatic factors. We conclude that the re-cultivation of ex-arable land should be avoided and management practices on arable land should be optimized to enhance land use sustainability. Conservational tillage practices are not only beneficial for agricultural production and the preservation of soil carbon stocks but also allow grasshoppers as a component of biodiversity to reproduce on arable land.

# SESSION 20 – SPECIES TRANSFER

Chair: Anne Tolvanen

Need advice on how to make mosses grow in your restoration site? Beautiful grassland flowers, endangered bulrushes or seagrass? These posters take you through ecosystems from the mountains to the shores and they show you how to get your target plants there, too.

SESSION 20-P1 – SPECIES TRANSFER

## HAYSEEDING – A TRADITIONAL PRACTICE TO RETURN SEED DIVERSITY TO HAY MEADOWS IN THE EASTERN CARPATHIANS

Orsolya Valkó<sup>1</sup>, Dániel Babai<sup>2</sup>, Péter Török<sup>3</sup>, Katalin Tóth<sup>1</sup>, Zsolt Molnár<sup>4</sup>, Balázs Deák<sup>1</sup>, András Kelemen<sup>1</sup>, Tamás Migléczi<sup>1</sup>, Ágnes Albert<sup>3</sup>, Béla Tóthmérész<sup>1</sup>

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We studied a traditional management practice called hayseeding in the Eastern Carpathians (Romania) where species-rich semi-natural grasslands cover a considerable area. Local people have maintained the grasslands by a well-developed, low-input farming system for centuries. Hayseeding is an integral part of this system: farmers sweep the mixed seed material from the barns and use it for overseeding manured meadows in spring; thus, a considerable part of the removed seeds can be returned to the meadows. Our aim was to study the germinable seed content of the hayseed and to evaluate its role in the maintenance of the biodiversity in meadows. We collected 0.5 l of hayseed originated from sixteen meadow stands and germinated their seed content in greenhouse. In total more than 80,000 seedlings germinated from the hayseed samples, belonging to 71 species. We detected several rare species in the hayseed which were absent from the vegetation of the meadows, such as *Campanula abientia*, *Cardaminopsis halleri*, *Carex lepidocarpa* and *Thlaspi kovatsii*. We found that hayseed contains an extraordinarily high number and diversity of germinable seedlings. In general, approximately 60kg of hayseed is sown in each meadow, which means that more than 600,000 viable seeds are re-introduced to a certain meadow. We found that hayseeding plays an important role in species dispersal within the landscape and considerably support the biodiversity of meadows.



## SEAGRASS TRANSPLANTATION TO RESTORE COASTAL LAGOON (HABITAT 1150\*) AND MEET WFD 2000/60/EC REQUIREMENTS: SECOND YEAR RESULTS OF LIFE SERESTO PROJECT IN VENICE LAGOON (ITALY)

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The northern Venice lagoon (SCI IT3250031) experienced a wide seagrass regression at the end of 20<sup>th</sup> century. After the enactment of laws aiming at reduction of anthropogenic pressures at the watershed scale, in the 2000s the water quality improved and environmental conditions suitable for seagrass growth were restored. The LIFE SeResto (LIFE12 NAT/IT/000331) project started in 2014 to trigger the natural re-colonisation of aquatic angiosperms by means of low-cost, small-scale manual transplantation mainly of *Zostera marina* and *Z. noltei*, at 35 shallow sites. Since seagrass meadows play a key role for coastal lagoon habitat conservation by supporting some biological communities, the proposed measure is expected to enhance the overall ecological status (*sensu* Water Framework Directive: WFD 2000/60/EC). In 2014, the restoration activities were carried out at 17 sites with an overall transplanted area of 10.9 m<sup>2</sup>; in 2015, they were completed at the remaining 18 sites. In this study, we present data from the first 17 sites. At the end of 2015 the average seagrass coverage within transplantation sites increased from 0% to 34.5%, with significant differences among sites (SD 40.6%). An intensive monitoring of water, sediment and biological parameters is ongoing to investigate both the factors affecting seagrass growth and to assess the improvement of environmental quality due to recolonization. Higher water transparency and lower trophic status seem to positively affect the seagrass growth. Macrophyte indicators highlight an improvement of aquatic environment quality, whereas plant coverage is still too limited to support changes of fauna.

## TRANSPLANTATION EXPERIMENT OF AN ENDANGERED PIONEER SPECIES: THE DWARF BULRUSH (*TYPHA MINIMA* HOPPE)

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The dwarf bulrush (*Typha minima* Hoppe) is a pioneer, light demanding species colonizing riparian flood plains of temperate mountain streams. Its number declined by more than 80% over the Alps and its larger remaining populations are located in French alpine rivers: Arve River, Durance River and Isère River. Due to the rising river anthropisation, *T. minima* is regularly impacted. Large scale engineering works on the Isère river have significant impacts on this protected species. These impacts have to be compensated by different methods including the restoration of viable populations. Our objective was to determine the best method to restore viable populations. Some *T. minima* clones were collected in wild populations and grown in a nursery. *T. minima* was then transplanted using three methods: bare roots, small container (9 cm diameter) and large containers (33 cm diameter). We monitored these restoration experiment implemented along the Isère River between 2013 and 2015 by measuring shoot frequency, rhizome growth and patch expansion. The poster will (1) present the results of these three transplantation methods, (2) discuss them in regard with environmental conditions of transplantation, and (3) discuss application perspectives for *T. minima* conservation.

## FORMATION OF MOSS CARPET ON ABANDONED PEAT-FIELDS PLANTED BY SPHAGNUM MOSS TRANSFER METHOD

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The north-American approach to revegetate abandoned cut-over peatlands was tested on two Estonian sites. Common bog *Sphagnum* species (*S. angustifolium*, *S. fuscum*, *S. rubellum*, *S. magellanicum*) or their combinations were cut with brush cutter from *Calluna vulgaris-Sphagnum* bog communities. 5–10 cm moss pieces were distributed on plots by 3x6 m in August 2007. Ten permanent subplots by 25x25 cm were nested into every plot and the coverage of plant species found in August every year since 2009. In 2014 the surface of subplots was levelled and moss biomass sampled. PCA applied demonstrates that the development of moss patches on plots varies significantly and successional vectors are divergent. The moss carpet was most successfully (with highest coverage) developed on subplots where mixtures of different species were distributed. This can be explained by peat surface micro-topography variations, as topmost peat moisture content varies considerably on uneven peat surface and *Sphagnum* requirement for substrate moisture content is species-specific. Obviously the distribution of species mixture on the uneven peat surface gives reasonable results. The probability that the specimen meets its favourable conditions on uneven peat surface is much higher when distributing a species mixture, compared with mono-species plantings.

## BRINGING BACK THE RARE – BIOGEOCHEMICAL CONSTRAINTS OF PEAT MOSS ESTABLISHMENT IN RESTORED CUT-OVER BOGS

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Restoration of cut-over bogs should aim to enable the re-establishment of rare but functionally important *Sphagnum* hummock species to reach goals of climate protection. To assess hydrological and biogeochemical constraints for their establishment, we transplanted hummock species into restoration sites in NW-Germany. Mosses were transferred as intact sods in June 2015. In July and October pore water was sampled 5 and 20 cm beneath *Sphagnum* sods and in control plots and analysed for phosphate, ferrous iron, ammonia, nitrate and total organic carbon (TOC). Furthermore, we estimated moss vitality and growth and took peat cores for elemental analyses. Results indicate that vitality during water level draw down in summer was negatively related to plant available phosphate in deeper peat layers. Moss growth was negatively related to TOC in upper pore waters in October. Concentration of ferrous iron in deeper pore waters was in general significantly higher beneath *Sphagnum* sods compared to control plots, suggesting a direct impact of hummock mosses on soil moisture. However, with an increase of water levels towards the winter, accompanied by increasing ferrous iron and phosphate in pore waters, moss vitality recovered. This suggests that actively transferred hummock mosses suffering temporarily from desiccation in the summer season are able to recover even under relatively high nutrient levels as long as water level and redox state favour an optimal supply of required nutrients.

## PURITY, FUNCTIONAL GROUPS AND TARGET SPECIES COMPOSITION OF ON-SITE THRESHING MATERIAL FROM MOUNTAIN MEADOWS

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About 22 ha grassland at an altitude between 430 and 700 m were threshed out for winning seed material in the Vogelsberg region (Hesse, Germany) in 2015. The harvested meadows were characterised by mosaics of Nardion and Trisetion meadows, partially in transition to base-rich Arrhenatherion, as well as wet meadows (*Calthion palustre*). The seed material was harvested i) between the beginning of July and the beginning of August (first cut) and ii) at the end of September (second cut) by using two different harvesters with fixed and pendulum mower. We took seed material samples (each about 50 g) with three replicates from seven meadows; 2–5 g were separated into seeds, chaff and impurities; furthermore, we identified and counted the seed number of target species. The seed weight portion ranged from 10 % to 47 % with decreasing yields at later cutting dates: late first cuts and second cuts yielded significant lower seed portions than earlier cuts. While late cutting dates showed an increasing proportion of forbs, the amount of grasses as well as grass-like species obviously depends on their overall occurrence. We could not find any impact of different mower types on impurity proportion. We identified an average target species number between 4.7 and 13.3. Our results point out the heterogeneity of on-site threshing material and the need of further research to identify rules for on-site harvesting of seed material.

## RESTORATION OF CALCAREOUS MEDITERRANEAN SITES FOLLOWING CONSTRUCTION OF PHOTOVOLTAIC POWER STATIONS – THE PIESO PROJECT

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The construction of photovoltaic power stations (PVPS) results in strong soil disturbance and destruction of existing vegetation. Subsequent management allows the restoration of low growing plant communities such as grass- or shrublands. In the framework of an interdisciplinary project (PIESO) aiming at an ecological integration of PVPS, different possibilities of ecological restoration are tested on calcareous Mediterranean sites. The PVPS of Roquefort-des-Corbières was chosen to analyse the effects of monospecific sowing of the keystone species *Brachypodium retusum*, hay transfer from an adjacent reference community, and a soil addition treatment favouring earthworm colonisation. The three treatments were compared with control plots of natural succession. Treatments and control were tested below and outside the area covered by solar panels in order to evaluate the panel effects and interactions with treatments. Solar panels change radiation and microclimate, which may result in substantial differences in colonisation patterns. The site is a former vineyard, and semi-natural *B. retusum*-dominated dry grasslands were used as a donor community for hay transfer. The experiment was set up in March 2016. The experimental protocol includes vegetation surveys and performance measurements of key plant species. We will further measure photosynthetically active radiation and soil humidity as the most important environmental factors differentiating plots below and outside solar panels.

## WATER SEDGE ESTABLISHMENT IN PEATLAND RECLAMATION

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Many peatlands have been lost to oil and gas disturbances in Alberta, Canada, and new provincial directives require peatland reclamation. Peat develops through the build-up of dead plant material when production exceeds decomposition; however, peat accumulation is very slow (0.5–1.0 mm/yr). Peatland reclamation is therefore focused on creating conditions favourable for the development of a peatland, rather than the creation of a peatland itself. Establishing peat accumulating plants is essential for the development of peatland conditions. Planting *Carex aquatilis* in optimal conditions for its establishment is predicted to be a successful approach; however, optimal growing conditions remain unclear. The objective of my study is to determine the survival and spread rates of *C. aquatilis* in a variety of peat depths and moisture regimes. Three sets of 1m<sup>2</sup> peat platforms (0, 5 and 30 cm) were installed at three elevation levels relative to the water table (to represent a spectrum of moisture conditions), resulting in nine treatment combinations. Each treatment combination is arranged in a randomized block design and replicated four times. Plants were collected from a natural marsh in the same provenance (summer 2013), and nine plants were randomly assigned to each plot. Preliminary results suggest that peat may not be necessary for *C. aquatilis* establishment, and that ideal moisture conditions are important for sufficient *C. aquatilis* cover. Peatland reclamation is becoming increasingly important and findings from this research will provide practical and theoretical contributions by increasing our understanding of ideal conditions for *C. aquatilis*, and by contributing to future peatland reclamation guidelines and designs.

## INTERACTION OF SEED TRAITS AND MOSSES DURING ESTABLISHMENT OF VASCULAR PLANTS ON RESTORED CALCAREOUS GRASSLANDS

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Topsoil removal and hay transfer are successfully applied to restore calcareous grasslands while mosses can locally become dominant, especially on bare gravel. There is evidence for facilitating effects of mosses on establishment of vascular plants, but other studies shown that mosses delay or even prevent formation of the target communities. We postulate that seed size and seed shape are key factors controlling the net effect of mosses on community assembly, because these traits determine whether a seed can penetrate the moss layer to germinate in the mineral soil, and whether a seedling can grow through the mosses. These interactions are potentially strong filters for community composition. In restored calcareous grasslands near Munich and in an associated greenhouse experiment the impact of mosses on emergence and survival of seedlings of 15 vascular grassland plants were investigated. The plant species were selected to represent three classes of seed size and seed shape, respectively. In the restoration sites, seeds were sown into microplots with or without cover of two common moss species (*Abietinella abietina* and *Rhytidium rugosum*). In the greenhouse, seeds were sown into pots with bare calcareous substrate as well as onto and underneath moss cushions. The experiments were done for 16 weeks, and seedling emergence and survival were recorded as well as plant biomass. Preliminary results show a significant negative effect of moss dominance on vascular plant emergence under field conditions, while hardly any effect was observed under controlled greenhouse conditions. Seed traits explained not the residual variation in emergence numbers, and no effect of the initial vertical position of the seeds in the moss layer occurred. We conclude that the effect of mosses on establishment of vascular plants is species-specific, and that highest diversity of calcareous grasslands will be achieved by a mosaic of bare soil and patchy dominance of mosses.

# SESSION 21 – LARGE-SCALE GRASSLAND RESTORATION IN EUROPE: PRACTICE AND PROSPECTS

Chair: Jonathan Mitchley

This symposium presents a series of case studies in grassland restoration across Europe. Each study is based on a large-scale project and/or long-term data collection. These studies demonstrate current best practice and allow evaluation of strengths and weaknesses and provide the basis for development of a strategy for landscape scale restoration in the 21<sup>st</sup> century.

SESSION 21-01 – LARGE-SCALE GRASSLAND RESTORATION IN EUROPE: PRACTICE AND PROSPECTS

## MONITORING CHANGES IN BIODIVERSITY PATTERNS AND IN LANDSCAPE STRUCTURE DURING THE LARGE-SCALE GRASSLAND RESTORATION IN ESTONIA

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One third of calcareous alvar grasslands in Europe occur in Estonia. During the past century, cessation of grazing and consequent overgrowing of grasslands with trees and bushes has led to extensive loss of alvar grasslands. The area of alvars in Estonia has decreased from 43,000 ha in the 1930s to only 2,500 ha of suitably managed grasslands nowadays. Declining area and increasing isolation of habitat patches has put many habitat specialist species under severe threat because of the extinction debt of characteristic plant and butterfly species. From 2014 to 2019, a large-scale restoration project "Life to Alvars" is carried out on Estonian alvars with the aim to restore 2,500 ha of most valuable alvar grasslands. The project is funded by the EU LIFE+ Nature programme and its activities include clearing of alvar grasslands from excessive shrubs and trees, re-introducing traditional grazing and raising the awareness of alvar grassland values among local people. To estimate the effect of restoration on biodiversity, a number of baseline indicators have been described prior the restoration activities. These indicators include the species diversity of vascular plants, mosses, lichens, spiders, millipedes, centipedes, butterflies, bumblebees, birds, mycorrhizal fungi, as well as plant genetic diversity. In addition, environmental, disturbance and landscape indicators were assessed and linked with biotic indicators. Here, we will present the first results of this extensive monitoring scheme.

## SETTING AND ASSESSING A LARGE-SCALE RESTORATION PROJECT: EXAMPLE OF A STEPPE GRASSLAND REHABILITATION PROJECT IN SOUTH-EASTERN FRANCE

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Restoring ecosystems at large scale is challenging: restoration techniques are mainly developed at small scales and large scale projects usually involve many stakeholders with different expectations. Our objective is to show how these constraints may be transformed into opportunities, and how to assess the success of a whole large scale project. We used as an example the rehabilitation of a former intensive orchard into a Mediterranean steppe in the La Crau area (south-eastern France). Because the 357 ha project involved several stakeholders, multiple objectives co-existed: creating biodiversity units for a mitigation bank, restoring traditional sheep grazing management, rehabilitating a suitable habitat for endangered steppe birds, and restoring the steppe plant community and the Coleoptera and Orthoptera community diversities, compositions and structures. Several restoration methods were tested at different scales and the overall project design was a trade-off between objectives, costs and opportunities. In order to have a global overview of success 7 years after restoration, we will present the results within a new framework for ecological restoration project assessment. It has three hierarchical levels: (1) the project is composed of objectives weighted by stakeholders, and a project score is calculated for each stakeholder; (2) the objectives is composed of weighted variables; and (3) the variables which are standardized in order to be comparable to each other.

## EFFECTS OF ECOLOGICAL RESTORATION ON INSECT ASSEMBLAGES (COLEOPTERA - ORTHOPTERA) IN A MEDITERRANEAN STEPPE RANGELAND

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The La Crau steppe area (southeastern France) has suffered from reduction and fragmentation of 80% of its initial surface mostly in the last century. Among the anthropogenic activities, an industrial orchard of 357ha, set up in 1987, was abandoned in 2006 and rehabilitated into a Mediterranean rangeland in 2009 for bird conservation purposes. Hay transfer, nurse species seeding (able to rapidly cover the soil surface and used in order to prevent non-target species from densely covering the soil surface) and soil transfer were also tested at the same time in order to restore the pre-existing steppe plant communities. Here, we aimed at assessing the effect of ecological rehabilitation and restoration treatments on Coleoptera and Orthoptera considering species richness, abundance, diversity and structure of these insects' assemblages. Seven areas were considered: the reference steppe, the three experimental restoration treatments (hay transfer, nurse species seeding and soil transfer), the rehabilitated area itself, the control and the edge between the steppe and the former industrial orchard area. Coleoptera were sampled with pitfall traps for 3 years (2011–2013). Orthoptera were captured with a sweep net for 4 years (2010–2013). Positive effects of soil transfer and nurse species seeding were measured for Coleoptera whereas strong differences in composition remained between the steppe and the various assessed areas. For Orthoptera, no significant differences were measured between control and reference steppe indicating that restoration did not significantly accelerate natural colonization. These results show the importance of considering several taxonomic groups for restoration success assessment.

## LANDSCAPE-SCALE RESTORATION OF SPECIES RICH GRASSLANDS ON CROPLANDS BY SOWING LOW- AND HIGH-DIVERSITY SEED MIXTURES

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Large-scale abandonment of croplands resulted in landscape-scale changes in biodiversity, ecosystem services and agricultural production. We studied vegetation changes in former croplands sown by low-diversity seed mixtures in East-Hungary. Our aim was to evaluate the usefulness of seed sowing. We also tested a novel approach by the establishment of colonisation windows for increasing the diversity of species-poor sown grasslands. We compiled a high-diversity seed mixture containing 35 species, and established colonisation windows (1×1-m, 2×2-m and 4×4-m size) in 8-year-old restored grasslands. Three years after sowing low-diversity seed mixtures vegetation was characterised by a high cover of sown grass species and low cover of weeds. Our results showed that using low diversity seed mixtures for grassland restoration offer a viable solution for restoring. By establishing colonisation windows we can successfully introduce target species to the species-poor grasslands. We found that all sown species established in the colonisation windows and many of them maintained or increased their first-year cover to the second year. Larger colonisation windows were characterised by higher cover of sown species compared to the smaller ones. Therefore, in restoration practice larger colonisation windows are recommended.

## REWILDING THE LANDSCAPE: EFFECTS OF LARGE-SCALE GRASSLAND RESTORATION AND MANAGEMENT ON ANIMALS

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Ecosystem restoration is often limited by socioeconomic constraints and monitoring typically focuses on plants and vegetation. As a result, we know little on how restoration affects animals. We studied changes in animal assemblages in the Egyek-Pusztakócs marshes (4,000 ha, Hortobágy National Park, E-Hungary), where 760 ha of cropland were restored to alkali or loess grasslands by seed-sowing in 2005–2008. We monitored orthopterans, spiders, carabid beetles and amphibians by sweepnetting and/or pitfall traps, and bees by plate traps. Birds were censused in point counts and small mammals were sampled by live traps. We compared species richness, composition and abundance among six habitat types (croplands, four ages of restoration, natural grasslands). We found that arthropod richness decreased after two years in most groups to levels typical in target natural grasslands. Orthopterans were exceptions as their richness doubled and abundance increased ten-fold compared to those in croplands. Arthropod species composition approached that of target grasslands in only three years. Amphibians increased considerably and birds increased slightly in richness and abundance, whereas small mammal abundance was determined primarily by local management and not by restoration. However, we found that small mammal survival during unfavourable periods was higher in areas with higher proportion of grasslands, thus, restoration can have landscape-scale benefits to animals. Our results demonstrate how restoration affects several animal groups and are applicable in ecosystem restoration and management but also help to interpret ecological concepts in animal assemblages such as succession and community assembly.



## GRASSLAND SUCCESSION IN FORMER LIGNITE MINING AREAS

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Between 1994 and 2002, abundance of plant species was determined on permanent plots in spontaneously developing mined sites in the Central German Lignite Mining District. We choose a chronosequence approach (six age classes: 0–5 yrs, 6–10 yrs, 11–20 yrs, 21–30 yrs, 31–40 yrs, >40 yrs; nine replicates) to compare spontaneously developing grasslands to grasslands actively restored via sowing or hay transfer. We found that grasses typical for dry calcareous grasslands were not able to immigrate spontaneously into mined sites. On the other hand, when these grasses were introduced at the onset of succession, establishment success was high. A GNMDS showed that grasslands restored by sowing or hay transfer developed faster towards ancient calcareous grasslands compared to spontaneously developing sites. We analysed effects of regional species pools, dispersal limitation and stochasticity on spontaneous succession trajectories, and how community structure and composition differ between actively restored mined sites and ancient natural grasslands. While dispersal stochasticity during spontaneous succession resulted in a higher  $\gamma$ -diversity, species introduction supports faster trajectories towards desired reference states. In using binary logistic regression, we showed that the probability to establish in mined sites increased with higher abundance in the vicinity, indicating the importance of high propagule pressure in a landscape context, whereas long-distance dispersal traits were significant, but less important. The key decision of whether to rely on spontaneous succession or not mainly depends on the surrounding landscape, the need for erosion control and/or rapid compensation for lost habitats.

## HIERARCHY OF FACTORS DETERMINING GRASSLAND RESTORATION ON ARABLE LAND

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In the White Carpathian Mts., Czech Republic, thousands of hectares of arable land have been converted into grassland after 1989. Since 2009 we have studied the influence of different restoration methods, soil factors, climatic factors as well as surrounding landscape on the restoration process. Altogether 35 grasslands restored with a regional seed mixture, 31 restored with commercial seed mixtures, 16 restored by means of spontaneous succession and also 23 permanent meadows were compared based on vegetation records (species cover in 5 m × 5 m plots). In order to assess vegetation changes, we defined 151 target plant species. The data were processed using multivariate and univariate statistics. During the research, 87 (58%) target species were found in the restored grasslands. Almost half of them (43) had been sown, whereas 44 target species had colonised the restored grasslands spontaneously. This means that the restoration potential (based on the rich species pool of xerothermic grasslands) has not yet been fully utilised, although there is development towards the targeted species-rich vegetation. We may conclude that factors determining grassland restoration on arable land have the following hierarchy: soil factors > restoration method > climate > time passed since start of restoration > surrounding landscape (mainly occurrence of permanent meadows in the vicinity and their frequency). Besides these, priority effects certainly play an important role.



## RESPONSES OF PHYTOPHAGOUS INSECT COMMUNITIES TO RESTORATION OF SPECIES-RICH GRASSLANDS IN THE WHITE CARPATHIANS (CZECH REPUBLIC)

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The White Carpathians (south-eastern Czech Republic) harbour large areas of well-preserved semi-natural grasslands with high floristic diversity. During the second half of the 20<sup>th</sup> century many of them were turned into arable land. Since 1980s some areas were restored through spontaneous succession and sowing of commercial (containing several grass and legume species) and regional (species-rich, composed of local herb and grass species) mixtures. In two projects in 2012–2014, we surveyed insect communities, namely leafhoppers and true bugs (Hemiptera: Auchenorrhyncha, Heteroptera), butterflies and burnet moths (Lepidoptera: Hesperioidea, Papilionoidea, Zygaenidae), leaf beetles and weevils (Coleoptera: Chrysomelidae, Curculionoidea) in restored and original species-rich grasslands to assess their biodiversity and restoration success. Butterflies were monitored by transect walks, the other insect groups were sampled by sweeping. In the first project, we compared 16 pairs of plots, each composed of a site restored (5–13 years ago) with the regional seed mixture and the nearest patch of a well-preserved grassland as a reference site. In the second project, we surveyed 17 sites of grasslands restored (8–25 years ago) with different methods and well-preserved original grasslands as reference sites. Restoration by all used methods (spontaneous succession, commercial and regional seed mixtures) was considered successful for the communities of leafhoppers, true bugs and phytophagous beetles, even though their species composition on restored sites significantly differs from reference sites at present. Butterflies and burnet moths have not responded that well: their communities on restored grasslands remain species-poor.

## GRASSLAND RESTORATION AT STONEHENGE WORLD HERITAGE SITE, UK

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A project to restore 540 ha of previously arable land commenced in 2000 within the boundary of the Stonehenge World Heritage Site, Wiltshire, UK. The project was initiated by the UK National Trust with the objective of enhancing biodiversity (dry calcicolous grassland) and landscape values. Since its inception, more than 500 ha within over 20 fields has been sown with regional seed mixtures harvested from adjacent species-rich calcicolous areas and restored fields. Botanical surveys have been carried out at intervals in the restored grasslands and in adjacent calcicolous grassland fragments in order to evaluate the rate and progress of grassland restoration. Measures of successful restoration include presence of plant indicator species (positive and negative) and Ellenberg indicator values and the presence of indicator invertebrates (Lepidoptera). Factors affecting successful restoration include time since sowing and soil and management factors. The results of monitoring are used to discuss a strategy for restoration of species-rich grassland at the landscape scale.

## HOW DOES CLIMATE AND MOWING AFFECT THE STABILITY OF FLOWERING IN *ERIOPHORUM LATIFOLIUM*? EXPERIENCES FROM LONG-TERM MONITORING

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Flowering and recruitment via seeds is an important aspect of the life history of plants, and factors that may affect flowering include climate, disturbance and cost of reproduction. We used time series of flowering density (annual data 1982–2008, 126 permanent plots) to determine the impact on flowering from climate, management (mowing, 62 plots) and cost of reproduction in the rich fen sedge *Eriophorum latifolium*. The study areas were restored hay fens in a coastal and an inland area in Norway. Cost of reproduction was the most influential among the factors affecting flowering. Dry conditions during the previous summer affected flowering density negatively in the coastal area, but had no effect in the inland area. We attribute this to differences in hydrology, with steeply sloping fens in the coastal area, and gently sloping, spring-fed fens in the inland area. Flowering increased with the length of the previous growing season (coastal area), decreased with the amount of precipitation during the previous spring (inland area), and increased with temperature in spring the same year (both areas). The climatic conditions during the previous year are more important than the conditions during the year of flowering. Mowing interacted with precipitation, and a wet spring and summer in the previous year had a negative impact on flowering in mown compared to unmown plots. The future climate in Norway is likely to be wetter and with higher variability in precipitation. This may result in larger variation in flowering among years, and the impact of mowing seems to be enhanced in wet conditions. One of the implications may be a lower flowering density in plant populations in managed and restored hay fens, and management plans should account for this.

## SØLENDET NATURE RESERVE – A RESTORED HAY-MAKING LAND

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For centuries, hay-making in outlying lands at Sølendet, Central Norway (62°40' N, 11°50' E) was essential for the farms in the nearby village Brekken. Until ca. 1950, about 200 ha were used for hay-making, and traditionally, about half the area was mown each year. The 10 landowners invested about 1000 days' work annually to harvest a total of 100 tons of hay. Based on our long-term studies, the hay yield per year averages ca. 100 g/m<sup>2</sup> when we mow every second year, but this varies between vegetation types from 55 to 175 g/m<sup>2</sup>. Mowing every year reduces the yield to about the half, explaining the traditional practice of mowing every second year. The area was protected in 1974, and restoration and active management commenced, including clearing of shrubs, thinning of trees and mowing using a two-wheeled tractor. Currently, 18 ha are managed intensively (similar to traditional use), 140 ha are managed more extensively with mowing every 5–10 years, and the remaining area is left as an unmown, overgrowing reference. During four decades of management, 800 ha have been mown in total, giving an annual average of 20 ha. Sølendet is dominated by rich fens and wooded grasslands used for hay-making, and these nature types are today red listed and protected. In a long-term research project using permanent plots, we study the succession in plant cover, and effects of restoration and management activities such as scything, trampling, burning and cattle grazing. A large number of papers (international publications, popularised presentations, research reports, etc.) have been published.

# SESSION 22 – TUNING UP GRASSLAND RESTORATION

Chair: Julia-Maria Hermann

Man got at least one thing right when he introduced extensive livestock farming in Middle Europe. How can we best preserve those species-rich flower meadows and pastures, and how restore them in a landscape that changes ever faster? Reducing nutrient loads is a major challenge, overcoming dispersal limitations of target species is another, and trees and shrubs try to reclaim land that was originally theirs. No restoration is successful without regular mowing or grazing thereafter, if possible, in economically sustainable fashion. This session features a variety of projects that bring us closer to achieving these goals.

SESSION 22-01 – TUNING UP GRASSLAND RESTORATION

## LIFE TO ALVAR: LARGE-SCALE ESTONIAN ALVAR GRASSLAND RESTORATION IN PRACTICE

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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. The main threat to the alvar grasslands is overgrowing with junipers and pine trees after grazing has ceased. This has caused the loss of nearly 85% of alvar habitat in Estonia: from 43,000 ha in 1930s to 7,000 by now. The “LIFE to alvars” project is targeting the key areas of alvar habitat in Western Estonia, aiming to restore 2,500 ha of alvars and to re-establish grazing in the restored areas. The restoration process of the overgrown alvar starts with the tree and shrub removal. Abandoned alvar grasslands are up to 80–100% covered with junipers and pine trees and 10–30% of the trees and shrubs remain after the restoration process. The main challenge of the project is to carry out large-scale restoration work within the time frames of the project. To achieve that, it was decided to use forestry and agricultural machinery to carry out the large-scale tree and shrub removal. There is little or no previous experience in alvar restoration using heavy machinery as this work was by hand previously. Four different types of machinery were successfully tested and are now used in alvar grassland restoration process. In 1.5 years, nearly half of the targeted area has already been restored and the work is quicker, less expensive and with better quality compared to the restoration done by hand. In average, about 300 hours of work are needed for 1 ha of alvar restoration by hand, and only about 60 hours when restoration is carried out by the machinery. Work done by machinery is about 40% cheaper per ha.

## RESTORATION OF SPECIES-RICH *NARDUS* GRASSLANDS ON FORMER FERTILIZED LAND BY REINITIATING MOWING AND GRAZING IS INADEQUATE

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Past intensive land use and more specifically, elevated phosphorus levels, complicate the successful restoration of species-rich grasslands. Aiming to deplete nutrients, managers often reinstall traditional haymaking management, sometimes combined with grazing. Here, we evaluate this technique's effectiveness in achieving its goal. We selected seven post-agricultural grasslands, in Flanders, Belgium, which had elevated nutrient levels after the cessation of intensive agriculture, and which were under traditional grassland management for 16–24 years. We compared soil and vegetation data with 34 *Nardus* grasslands. Reinstating traditional grassland management did not cause community composition to resemble that of the target. Furthermore, bioavailable P-concentrations and soil pH remained significantly higher in the seven post-fertilization grasslands. Given these results, we propose a decision framework to aid planners and managers in their choice of interventions. First, habitat loss should be avoided. Second, cost-effective efforts for restoration should be well-prepared including measurements of important initial soil characteristics. This allows an evaluation of "distance to target" and selection of an effective restoration technique. Restoration should focus on fields with low bioavailable P-concentrations, preferably adjacent to well-established communities of the targeted vegetation type. We conclude that restoration of oligotrophic *Nardus* grasslands on intensively fertilized soils by traditional grassland management techniques is unrealistic, at least in a timespan of decades. Topsoil removal should be considered as an alternative practice, or else, a less oligotrophic habitat type should be targeted.

## ASSESSING THE FUNCTIONAL EFFECTS OF RESTORATION MANAGEMENT: A TRAIT-BASED ANALYSIS FROM 25-YEAR FIELD EXPERIMENTS IN WET GRASSLANDS OF NORTHWESTERN GERMANY

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Success of restoration management should not only be evaluated via comparing similarity in species composition between restored and reference sites, but also by using functional community diversity and composition. In this context, plant functional traits may offer additional insight into the mechanism of the restoration process. Here we present a long-term study assessing different management treatments of nine sites in wet lowland meadows in Northwestern Germany: Treatments include mowing once (early and late), mowing twice and leaving fallow. Vegetation was recorded every second year since 1987. Additionally, after 26 years, soil seed banks were sampled at two depth levels. For seed bank and vegetation records, functional composition (CWMs) and diversity (Rao's Q) were calculated for selected plant functional traits. Regarding above-ground vegetation, strong time lags and fluctuations in response to the restoration treatments occurred, pointing to the pitfalls of short-term observation. Mowing twice a year achieved highest plant species richness and functional composition remained closest to the initial vegetation. Functional diversity increased over all treatments with time, but least so in the fallow. Seed bank of all treatments showed high diversity concerning traits related to competition and regeneration, indicating that the seed bank could act as insurance for meadow vegetation after severe disturbance. Outcomes of our study can help to monitor and evaluate grassland restoration projects not only on a taxonomic but also on a functional basis.

## OLD-FIELD SUCCESSION THEORIES REVISITED FROM THE VIEWPOINT OF PERENNIAL-CROP-MEDIATED SUCCESSION

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We compared perennial-crop-mediated succession (the initial assemblages are dominated by perennials) with classical old-field succession (succession of abandoned annual croplands or after the complete removal of cultivated crop) from a restoration ecological viewpoint. We recorded the percentage cover of vascular plants in 1-, 3-, 5- and 10-year-old extensively managed (mown twice a year) alfalfa fields in the Hortobágy, Hungary. Our study sites were originally covered by loess grasslands. Although the initial stages of these two successional ways are quite different, some processes show striking similarities in the case of temporal changes of species and functional diversity, resource acquisition vs conservation trade-off, and seed dispersal strategies. However, we also demonstrated that in perennial-crop-mediated succession, there are remarkable differences compared to classical old-field succession: (i) Weed cover was permanently low (less than 10%). (ii) There was no litter accumulation, (iii) no increase of total biomass and (iv) functional evenness as the age of fields increased. (v) The competitive character of communities remained unchanged during the succession. According to our findings the initial stages of perennial-crop-mediated succession were similar to the middle stages of classical old-field succession. However, the alfalfa, in contrast to perennial mid-succession grasses, is a short-lived perennial characterised by a typical decline of its stands 3–5 years after its establishment, and therefore does not arrest the succession in an unwanted stage. Moreover, the lack of a weed-dominated stage and of litter accumulation is also favourable from a restoration viewpoint. We found that after a decade of regular mowing, alfalfa fields were transformed into loess grasslands dominated by native perennial grasses; however, the characteristic forbs of loess grasslands remained rare.

## RESTORING THE HABITAT OF CORNCRAKE (*CREX CREX*) ON ARABLE LAND: THE CHALLENGE TO IMPROVE THE SOIL NUTRIENT STATUS AND HYDROLOGICAL CONDITIONS

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A full implementation of the Habitats Directive implies that all enlisted habitats and species attain a favourable conservation status all over the European territory. In Northern Belgium an expansion of natural landscapes and forests by 25,000 ha is necessary. To fulfil this target, a conversion of nutrient enriched agricultural land is often needed. The restoration of habitats on former agricultural land has shown variable success. One of the most important bottlenecks for ecosystem restoration on former agricultural land is the large stock of nutrients, in particular nitrogen and phosphorus. Human efforts to restore nutrient-poor conditions likely become an increasingly important aspect of biodiversity conservation. Corncrakes are strongly associated with agricultural grassland managed for the production of hay. Suitable habitats include moist, unfertilized grassland and regularly cut meadows in areas of low-intensity agriculture where vegetation grows tall in summer. To restore suitable habitat, it is necessary to improve the soil nutrient status and hydrological conditions. In this talk we give insight in the agricultural parcel's potential for restoration of semi-natural grasslands under iron-rich conditions. We discuss measures that can be undertaken to restore the soil nutrient status and explain possible changes in soil chemistry after rewetting. We also briefly give some options for enlarging differences in vegetation structure.

## HAY TRANSFER TO RESTORE FLOODPLAIN GRASSLANDS: HOW IMPORTANT ARE DATE AND SOIL PREPARATION ?

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Hay transfer is increasingly used to improve the success of ecological restoration in dispersal limited ecosystems such as floodplain grasslands. Since plant species differ in phenology, the cutting date may largely influence species composition. Additionally, restoration success depends on the competition between transferred species and preexisting vegetation representing a strong environmental filter. In a full-factorial experiment, we tested the effects of transfer date and of soil preparation reducing competition on community assemblage and key species abundance. The transfer date treatments were spring hay, summer hay and a combination of both. The competition treatments included deep tillage, shallow tillage and an undisturbed control. The experiment was set up in 2007 on a former cereal field of the Biosphere Reserve "Mittlere Elbe" (Eastern Germany) converted to extensive grassland management in 1993. Vegetation and key species abundance were surveyed until 2015. The study showed that soil preparation prior to hay transfer clearly increased seedling recruitment of transferred plant species confirming the importance of competition. Species composition strongly depended on the date of transfer. Species diversity was not different between spring and summer hay but corresponding to their phenology, key species abundance was much higher in the late hay treatment. The best results (diversity, key species abundance) were obtained for a combination of spring and summer hay.

## PRIORITY EFFECTS INFLUENCE PLANT TRAITS AND BIOMASS IN A GRASSLAND FIELD EXPERIMENT

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Species that arrive first can affect further assembly (priority effects). This can alter ecosystem functioning and ensuing species diversity. Species-rich grasslands in central Europe are endangered by agricultural intensification and land abandonment; any incentive for farmers to keep managing grasslands for diversity and higher productivity would be a gain. To complement the more general talk about priority effects of Temperton *et al.*, we report here results of the Priority Effect field experiment in Jülich, Germany. We altered the sequence in which plant functional groups (PFG-legumes, grasses, forbs) arrived in the system as well as sown diversity (9 or 21 species). We hypothesize that PFG order of arrival and sown diversity would affect aboveground biomass and plants traits. We measured aboveground biomass from 2012 to 2015 and plant traits (height, Specific Leaf Area-SLA, leaf water content, total N and  $\delta^{15}N$ ) in 2014. PFG order of arrival affected aboveground biomass over time: higher values were found where legumes were sown before other groups in 2012, 2014 and 2015. Sowing high diversity lead to more biomass in 2013. Plant traits varied depending on which PFG was sown first and which diversity was sown, with a trend to higher values when legumes were sown first. We infer plants traits can influence their ability to establish in a community, as well as play a key role in N cycling. Priority effects created by order of arrival and sown diversity, affecting plant biomass and traits, can influence the trajectory of a system and this could be applied in trying to achieve specific goals in grassland restoration.

## HOW MOWING FREQUENCY AFFECTS GRASSLAND FLORA AND FAUNA: IMPLICATIONS FOR RESTORATION AND MANAGEMENT OF SEMI-NATURAL GRASSLANDS IN EUROPE

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Management is an essential part of the restoration and conservation of biodiversity in valuable semi-natural grasslands of Europe. However, despite being crucial from a nature conservation point, the evaluation of effects of different management intensities is often challenging, partly because of the difficulty in objectively assessing management intensity levels. Mowing frequency, however, represents a clear-cut factor of biomass removal rate. In the present contribution, we reviewed all European studies that compared different mowing frequencies. Using regression models and meta-analyses we evaluated the effects of different mowing frequencies on grassland flora and fauna and determined which is most beneficial to ensure that high biodiversity is achieved and maintained in semi-natural grasslands. Our results will support both practitioners and policy makers in fulfilling goals for both restoration and continued management of valuable species-rich grasslands across Europe.

## INSIGHTS FOR RESTORATION: INTERACTIONS OF STOICHIOMETRIC AND PLANT FUNCTIONAL TRAITS MODULATING COMMUNITY COMPOSITION

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Successful ecosystem restoration requires understanding fundamental mechanisms and their interactions of community assembly and ecosystem functioning. Land-use intensification strongly affects biodiversity and community composition, which can be ascribed to specific plant characteristics modulating species responses to environmental factors. These functional traits reflect strategies for reproduction and dispersal, depict resource capture strategies and disturbance or competition tolerance within communities. Thus, they have become increasingly interesting for understanding and predicting plant community responses to management and restoration attempts. We assessed stoichiometric and functional trait composition and variability of 150 grassland plots in three regions in Germany within the framework of the Biodiversity Exploratories project. Aiming at disentangling responses of species profiting from reduced land-use intensity, we analysed leaf nutrient contents and functional traits of “loser” and “winner” plant species along a land-use intensity gradient. Our results show that despite being most productive, winners are relatively homeostatic in their nutrient stoichiometry, while losers (mostly rare species) are less homeostatic, retaining nutrients and investing them in heavier seeds. By specifically considering interactions between stoichiometric and traditional plant functional traits and responses to management our study helps to improve grassland restoration projects.



## ENRICHING PLANT DIVERSITY IN GRASSLANDS: IMMEDIATE EFFECTS OF SWARD DISTURBANCE, SEED ADDITION AND ENVIRONMENTAL FACTORS

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Biodiversity of temperate grasslands still drastically declines in many places. For this reason, restoration of plant diversity is no longer restricted to conservation areas but might also incorporate “typical” agriculturally used grasslands. However, due to seed and dispersal limitation, even low-intensively used grasslands remain species-poor over decades, although these sites hold a vast biodiversity potential. Here, we present a large-scale seeding and disturbance experiment in agricultural grasslands in three regions in Germany. The experiment was conducted in the framework of the “Biodiversity Exploratories” project for functional ecosystem research ([www.biodiversity-exploratories.de](http://www.biodiversity-exploratories.de)). We tested the application of sward disturbance and seed addition using a regionally produced seed mixture. After two years of the experiment, we assessed effects on plant diversity and seedling emergence. Our results indicate an immediate success of the combination of disturbance and seed addition, increasing plant-species richness by 25–50%, depending on study region. Thus, we have to stress the relevance of seed and dispersal limitation for grassland vegetation and recommend the described approach to significantly enrich plant communities using locally produced seed mixtures. In the future, this procedure could become more common if rewarded more directly by the incorporation into agri-environmental schemes.

## THOUSAND-SEED-WEIGHT AND GERMINATION ABILITY OF NATIVE SPECIES USED IN GRASSLAND RESTORATION IN HUNGARY

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Knowledge on germination ability and thousand-seed-weight data of native species can support grassland restoration to better estimate necessary seed amount. The aim of our restoration project is to reconstruct a mosaic of steppe oak forest and grasslands by different seed introduction methods. In the present study we measured seed weight and tested germination ability of 17 sown species with and without cold-treatment, and compared germination success with field establishment success. Seed sorts of 800 seeds were counted to measure thousand-seed-weights. Germination of 4 x 100 seeds per species was tested with or without cold treatment. Seeds were placed on sterile, wet filter paper under room temperature and germinated seeds were counted weekly. Based on the results of thousand-seed-weights, significant differences were detected by Mann-Whitney non-parametric test for four species compared to literature data. We have new data on the germination percentage of two dominant grasses of sandy grassland (*Festuca pseudovina* and *F. vaginata*). Cold treatment decreased the germination probability of four grass species, while two dicots germinated significantly better after the cold-treatment, tested by ANOVA. Germination success was much higher in laboratory conditions than establishment success under field conditions, where establishment was influenced by several factors (drought, competition etc.). Our data support the estimation of native seed amount required in restoration projects.



## TEMPORAL CHANGES OF COMMUNITY ASSEMBLY FILTERS IN A PANNONIAN SAND GRASSLAND RESTORATION

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Filter-based assembly models can support ecological restoration, as the separation of filters representing dispersal, abiotic and biotic constraints help to decide on restoration interventions. Environmental change in time can widen or constrict ecological filters, but the temporal changes of filters are yet poorly understood. We tested the temporal changes of filters in the restoration of endemic Pannonian sandy grassland in a microscale experiment (1 m<sup>2</sup> plots) based on three types of treatments according to the key filters: seeding of five species in 2002 (dispersal filter), carbon amendment of 45 g sucrose/m<sup>2</sup> every 3 weeks (abiotic filter) and mowing once in September (biotic or disturbance filter). We used the coefficient of determination ( $R_2$ ) as a measure of effect importance for the applied treatments on different indicators (species richness, vascular and moss cover, life form groups, grassland species and neophytes) based on mixed models. Not surprisingly, the importance of treatments and their change in time differed according to the indicator. Seeding showed the highest importance for most indicators related to species composition, with an increasing trend in most cases, except for species richness and grassland species. Carbon amendment had the strongest importance with an increasing trend related to moss cover. Mowing had the strongest importance related to litter and bare ground, and a lower, but increasing importance in case of long-lived forbs and grassland species. The importance of filter interactions was low for most studied indicators, but showed an increasing trend in some cases. Our study demonstrates the importance of temporal changes of filters, but the time scale used (6 years) is still limited.

## EFFECTS OF FUNCTIONAL DIVERSITY AND AN INVASIVE PLANT SPECIES ON SOIL NUTRIENT AVAILABILITY IN GRASSLAND MICROCOSMS

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Plant biodiversity positively affects ecosystem functioning, whereas invasive alien species (IAS) can compromise ecosystem functions. More diverse communities can resist plant invasions due to a complementary use of limiting resources. We performed a microcosm study to test if native functional diversity could reduce the impact of IAS on soil nutrients and plant biomass in grasslands. The factorial experiment was done in trays of 40 × 60 × 8 cm<sup>3</sup> with a mixture of peat, quartz, sand and clay powder (2:1:1:1), including three levels of functional diversity with and without the IAS *Solidago gigantea*. Target variables were soil nutrient availability and accumulation, native plant emergence and aboveground biomass. We applied a structural equation model to evaluate if diversity effects directly control soil nutrients or indirectly via plant biomass and soil water quality. Functional diversity positively affected soil nutrient availability and accumulation, whereas the IAS negatively influenced native plant biomass, soil nutrient availability and accumulation. There was little evidence that functional diversity prevents plant invasions in restored grasslands. Thus, grassland long-term functioning can be compromised by IAS, since they interfere with the effects of plants biomass and soil water quality on nutrient dynamics. Restoration of degraded grasslands should include a wide variety of plant traits to prevent invasions and to ensure ecosystem functioning.

# SESSION 23 – UNASSISTED RESTORATION: PITFALLS AND PROGRESS

Chair: Anton Fischer

“Restoration” in many cases means ecosystem development organized and assisted by humans. Also without any human management, however, sometimes ecosystems are set back to an earlier stage of development or into a quite new constellation of environmental factors and of species. After such “disturbances” the ecosystem spontaneously and without any input of man starts to develop back to a stage, which may be similar to the stage before disturbance or impact, respectively. For example, during a storm event, coniferous trees may be thrown down, and the structure of the stand will change totally; but some decades later it may again be a coniferous forest. After a mudflow, even soil material and soil structure may be completely different than before the event, but (depending on the general climate conditions) a new forest will emerge after a while. While most of the formerly managed forest stands, released to a free succession (e.g. declared a protected area without management), will develop to a stage of increased naturalness, semi-natural grasslands or arable field ecosystems will totally disappear after the abandonment of human impact.

In this session we want to discuss the current state of knowledge on the natural processes bringing vegetation stands (back?) to another/higher developmental stage. Not in each case “assisted development” is needed – in several cases the restoration work can be done by nature itself. Nevertheless, for landscape planning a good knowledge of the involved ecosystem processes is important to decide, where and when such unassisted restoration may lead to which kind of ecosystems, and which time span may be involved. Examples from all kind of terrestrial ecosystems all over the world are welcome. We are interested in the principles behind the single case studies.

## DON'T OVERLOOK NUTRIENT EFFICIENCY IN EXPLAINING PRINCIPLES OF SPONTANEOUS REVEGETATION OF SEVERELY ALTERED HABITATS

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Extreme conditions of strongly altered man-made landscapes as “accidental experiment” sites can be uniquely suited to provide fundamental insights into restoration processes. We studied unassisted revegetation of a floodplain in Eastern Serbia (formerly calcareous soils in a xerothermic surrounding), where long-term and large-scale pollution by sulphidic Cu tailings created a spatially explicit mosaic of drastically changed soils (nutrient deficiency, high Cu availability, or pH lowered by 4 units). Using a gradient approach framework and multivariate analysis of soil, vegetation, and leaf mineral composition, we found a functional response of restored vegetation primarily to mineral stress, while the surrounding vegetation had variable importance for restoration outcome. Under severe environmental filtering, physiological adaptations (reflected in homeostasis of leaf mineral elements, particularly of N:P ratio) can underpin clear vegetation patterns in early succession. When left to its own, nature coped differently with the imposed soil constraints. After over 50 years, excessive Cu concentrations still allowed convergence to the original poplar forests, while low pH combined with nutrient deficiency resulted in novel, depauperate assemblages of species typical for cooler and moister climate. This study shows that focus on filtering for nutrient efficiency can help to understand occasionally surprising outcomes of unassisted restoration of strongly altered sites.

## SUCCESS OF SELF-REVEGETATION ON PEAT-FIELDS AND PEAT PITS ABANDONED OVER 30 YEARS AGO

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The aim of the study was to understand the relationships between plant cover structure and habitat parameters (depth to water level – DWL, water pH, electric conductivity – EC, and Ca, Mg, Fe content, topmost peat N, P content). Plant cover was analysed and samples for characteristic habitat parameters were collected on a total of 90 plots (2 m x 2 m) on 19 Estonian peat-fields with areas from 30–130 ha, abandoned between 1965 and 1985, and on peat-pits abandoned in the 1950s. In total, 45 vascular plant species and 31 moss species (incl. 14 of *Sphagnum*) were found. The vascular plant species coverage on peat-fields was significantly positively related with the N and P content in the surface peat if the DWL was below 30 cm. If the DWL was less than 10 cm, the coverage of dwarf-shrubs decreased. The development of *Sphagnum* carpets was successful if DWL was close to surface, but the species composition was also related with water EC. The peat-pits had well developed *Sphagnum* carpets, dominated by hollow species and with small patches of hummock species. If DWL in peat-fields was near the surface, the plant cover structure was close to that found on peat-pits. It can be concluded that in favorable conditions (stable and high water level) the formation of plant cover with structures similar to natural bogs may last more than 30 years.

## PRIMARY SUCCESSION SEEN THROUGH SHIFTED PATTERNS OF SOIL MACROFAUNA SURFACE ACTIVITY, A DIFFERENT ECOLOGICAL PERSPECTIVE TOWARDS POST MINING SITES

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Trait distribution has been less used in the study of plant interactions with other trophic levels. In 2013, we studied the effect of plant traits on soil macrofauna surface activity in bare, grassy and woody patches of 10-, 18-, 28- and 55 years old sites, in the NW Czech Republic. The understory vegetation traits, e.g. LDMC (leaf dry matter content), and seed mass were identified. Soil fauna were collected and identified to family (larvae and adults were recorded as separate units due to their difference in ecology). Community weighted means of faunal surface activity (using the ecological grouping of fauna, clustered based on their recorded growth state and related surface activity into epigeic and endogeic) and plant traits were calculated. Site age, patches, and plant traits as explanatory variables were used for our CCA analysis. We infer that the observed endogeic community shift towards developed soils under older sites, besides its positive correlation with higher LDMC, is the result of a proper soil medium condition (as an environmental selection force) and its consequent successful colonization of fauna. This shift highlights the importance of soil development for a stable colonization and regeneration of migrated communities. Traits related to the surface activity of fauna and related plant traits have the potential to help us achieve an enhanced perception of the community pattern dynamics through time and space in post-mining primary successional cases.

## TRANSPORTATION OF DEVELOPED SOILS INTO PRIMARY SUCCESSIONS AFTER 20 YEARS: A GOOD CANDIDATE FOR INDUCED BIOLOGICAL COLONIZATION?

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The distance between well-established communities in undisturbed landscape and newly exposed material in the primary succession sites represent an important constraint to succession. In 2015, sampling was conducted in Sokolov post-mining sites, in a site inoculated 20 years ago by transporting developed soil blocks, to test the possibility to overcome the aforesaid case. Samples were taken in each control plot, transported soil, and soil in 2-m vicinity of the transported soil. Fauna were extracted and identified to family. According to the analysis, among 41 different soil macrofauna families, some (e.g. Diplopoda, Lumbricidae) were only significantly higher in the transported soil. This case is reasonable to be considered as a result of more appropriate moisture, food and protection levels provided in the well-developed soil. Similar to the transported soil, the adjacent original soil was already colonized by roughly equal population levels of springtails, although none of the mesofauna communities were able to migrate and possibly colonize longer distances as far away as the control plots. Based on the results, the presence of fauna for colonization is mandatory but not sufficient for its success. A well-developed soil, or at least a soil satisfying the basic properties on which the faunal communities depend, is the other side of the frame to be included in order to understand and predict the possible outcomes of any planned inoculation.

## IMPORTANCE OF POST-INDUSTRIAL SITES IN THE NATIONAL NETWORK OF PROTECTED AREAS IN THE CZECH REPUBLIC

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Nowadays, there is sufficiently evidence that various post-industrial and other human-made sites are crucial for protection of a substantial part of Central European biodiversity. It is typical that institutional conservation is often delayed in reflecting novel scientific findings, especially in case of such controversial ones. On the other hand, numerous stone quarries, sandpits and other anthropogenic sites are already included in the network of the specially protected areas in many regions. We will summarise our analysis of presence of various post-industrial sites in the protected areas of the Czech Republic. Besides a general overview, we will focus on their importance for conservation value of individual localities. We will also confront their gradual inclusion into the protected areas network with the history of the research field Restoration Ecology, to test how the general consideration of disturbed sites by institutional conservation corresponds to a development of ecological research.

## **COLONIZATION OF DISTURBED SITES BY A CENTRAL EUROPEAN FLORA – NEW INDICATOR VALUES SUGGESTED**

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We used species frequencies in the database of successional series of various disturbed sites across the Czech Republic (DaSS, 2822 phytosociological relevés, 1022 vascular plant species) for calculation of two indices: Index of Colonization Ability (ICA) and Index of Frequency in Seral Stages (IFSS). Because colonization of newly-created sites by species is determined not only by traits of the species but also by their frequency in the surrounding landscape (mass effect), the ICA values are corrected by their occurrence in the Czech National Phytosociological Database (CNPd). The values were accompanied by information about the first, optimum, and last occurrence during succession represented by five successional stages (initial, early, middle, late, old) and by information about the highest percentage cover reached in the optimum stage. Some species characterizing especially synanthropic vegetation, vegetation of cliffs, scree and walls and acidophilous grasslands were statistically overrepresented in the successional series compared to CNPD. Some significant trends were found in participation of vegetation types during succession. Species with high scores for both indices will probably more likely to spread in landscapes continuously disturbed by human activity. Thus, our indices may help predict future vegetation changes and restoration success in the central European landscape.

# SESSION 24 – SOIL SEED BANKS AND SEED DISPERSAL - PROMISING SOURCES FOR RESTORATION

Chairs: Orsolya Valkó, Péter Török

The evaluation of vegetation changes and the restoration success is often restricted to the analysis of local aboveground vegetation. Dispersal in space and time i.e. spatial seed dispersal in form of seed rain and soil seed banks represent major but often unexplored factors of species diversity and vegetation change. Seed rain is one of the main drivers of species colonisation and responsible for the unassisted immigration of target species in restoration sites. Via seed rain several unwanted species and weeds can reach the restoration sites and can hamper the recovery process of targeted vegetation. Seed banks can preserve seeds of species characteristic to the original vegetation, thus, they might represent an important source of recolonisation. In contrast, seed banks can harbour seeds of unwanted species and can signalise degradation before it will be detectable in aboveground vegetation. Landscape composition, configuration and land-use changes can strongly influence the dispersal processes, the species composition and propagule availability both in seed rain and seed banks. The aim of the special session is to evaluate the role of seed banks and seed rain in ecosystem restoration by introducing case studies focusing on open landscapes and forested habitats. Studies introducing all aspects of seed banks and seed dispersal are welcome, with a special focus on implications for ecological restoration.

SESSION 24-01 – SOIL SEED BANKS AND SEED DISPERSAL – PROMISING SOURCES FOR RESTORATION

## WHERE ARE THE MISSING SEEDS? CONSTRAINTS AND OPPORTUNITIES RELATED TO SEED BANKS AND SEED TRANSFER WITH HAY IN FEN MEADOWS RESTORATION

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The soil seed bank (SSB) is the major source for recolonization after radical restoration such as topsoil removal. A lack of viable seeds of target species is a constraint. Hay transfer (HT) can change a trajectory of vegetation development towards more successful outcome. In a long-term drained peatland studied (Całowanie Fen), SSB was dominated by common grassland species or ruderals. Even in deeper soil layers the seeds of target species were absent. This was compared with reference fen of similar type. The top soil layers were investigated as well as the top 5 cm layer that was exposed after topsoil removal. First, in multivariate analysis the traits related to persistence and reproduction were included. Later, the traits related to dispersal and nutrient acquisition were explored. Analysis with the plant traits indicated that SSB is dominated by species producing large number of seeds of high longevity, and closely resemble degraded vegetation. Compared with the SSB, HT provided species with larger seeds and fewer abilities for dispersal. HT is a practical method but has its shortcomings. Grasses were dominant in the seeds of HT. Suitable establishment conditions for the typical species need to be ensured immediately after the dormancy is broken, and this can be a matter of several weeks during the first months of the growth period. Elevated concentrations of substances impeding seedlings growth, local acidification or even prolong drying of bare peat surface can considerably hamper the establishment and result in elimination of the target species. As other studies have shown: the same SSB can result in different communities, depending on the germination and establishment conditions.

## PLANT DISPERSAL TRAITS IN FRAGMENTED HABITATS: IMPLICATIONS FOR RESTORATION

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Spontaneous recovery of characteristic vegetation is frequently desired during habitat restoration. Species composition and landscape structure, most importantly distance and area of the patches of the same habitat type in the surroundings play the key role in the success of spontaneous recovery of restored habitat. Out of all potential colonizers, species with better dispersal abilities are expected to arrive faster, being adapted to moving between habitat fragments. However, seed dispersal capacity is often negatively related to its ability to compete and establish. Also, with too large distances between habitat patches, species with long-distance dispersal ability are disfavoured due to large proportion of establishment failures when dispersing to inhospitable matrix habitats. Thus, dispersal and establishment ability of potentially colonizing species as well as the composition of the surrounding landscape are highly important while counting on spontaneous recovery of vegetation during restoration. Here, we use the data from European grasslands to test to what extent dispersal-related traits such as dispersal distance, dispersal mode and seed mass are related to habitat spatial characteristics and landscape structure, and explore what implications these relationships have for habitat restoration.

## NUT DISPERSAL BY MAGPIES IN AGROFORESTRY SYSTEMS

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Birds from the *Corvidae* family are main vectors for the dispersal of nuts of key tree species of the Northern hemisphere temperate forests, such as Fagaceae (oaks, beech) or Juglandaceae (walnuts). However, the role of magpies (*Pica pica*), the most abundant corvid of Europe, as nut dispersers has been little studied, and its contribution to the dispersal of these trees is considered anecdotal. Furthermore, the studies that analyse seed dispersal by corvids rarely address the fate of dispersed seeds, a prerequisite for assessing dispersal effectiveness. We analysed nut dispersal by magpies in two agroforestry mosaics in Spain using radio-tracking and video-recording. Transmitters were inserted in *Quercus ilex* acorns (central Spain) and *Juglans regia* nuts (south Spain) and placed in feeders. After dispersal, cached nuts were located and replaced by another intact nut, whose fate was periodically monitored until the germination period. Magpies dispersed both species up to distances of 112 m in central Spain (average 31 ± 24) and 157 m in southern Spain (average 40.6 ± 5 m). A portion of the cached nuts survived until the seedling emergence period in both sites, providing therefore the opportunity for seedling recruitment. Our results highlight that magpies are effective nut dispersers and are relevant for forest densification and expansion in Mediterranean agroforestry systems, a habitat where other important nut-dispersing corvids such as jays are absent.

## SEED ADDITION AND SEED-BED PREPARATION BY SHEEP IN ECOLOGICAL RESTORATION

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Low-intensity grazing is an effective tool for conservation and restoration of semi-natural, open vegetation. In the fragmented Central European landscape, sheep are the most prominent ungulates to functionally connect separated open habitats. We studied whether guided sheep flocks have the potential to add seeds to degraded habitats and to support seedling establishment as a consequence of trampling. Our focus vegetation type was open, threatened sand vegetation in the Upper Rhine Valley, Germany. In a first step, we quantified the role of sheep as seed vectors in these systems and found high numbers of vascular plant species (93 taxa) and seeds in the fleeces and/or faeces. In a second step, we aimed at quantifying and better understanding post-dispersal processes. We found that sheep trampling has the potential to enhance establishment success by incorporating seeds into the soil or by cracking of dung pellets. We conclude that sheep supply valuable combined effects to grazed open vegetation: They assist plant species in reaching new sites and in successfully colonizing these sites.

## WHAT IF SOIL SEED BANK AND SEED RAIN FAILED? A CASE STUDY WITH SANDY GRASSLANDS

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Xeric sandy grasslands are protected in the European Union (EU) (Natura2000 code: 6120). This habitat has however an “unfavourable-bad” conservation status in all EU biogeographical regions. Successful vegetation restoration depends on seed availability, either from the soil seed bank or seed rain. Because of the high level of fragmentation, habitat patches are spatially isolated, which makes seed dispersal from surrounding grasslands unlikely to occur. Consequently, habitat recolonization after restoration is only possible through the presence of a persistent seed bank in the soil. We examined the soil seed bank (composition, density and distribution across two soil layers) and the above-ground vegetation in 20 plots of existing and recently restored sandy grasslands (*Sedo-Cerastion*) in southern Belgium. Only a small number of the species recorded in the above-ground vegetation germinated from the soil seed bank samples. Most of the species that germinated were common species with large ecological amplitude (e.g. *Arenaria serpyllifolia*, *Poa annua*, *Rumex acetosella*), already present in the site. The typical sandy grasslands specialists (e.g. *Cardaminopsis arenosa*, *Dianthus deltoides*, *Helichrysum arenarium*, *Petrorhagia prolifera*) were missing from the seed bank except when present in the plot above-ground vegetation. Successful sandy grassland restoration may therefore require to artificially introduce seeds of target species. Examples of ongoing projects are discussed.



## SEED BANK AND SEED RAIN STUDIES IN TROPICAL GRASSLANDS AND MEDITERRANEAN ECOSYSTEMS: LESSONS LEARNT FOR RESTORATION

Elise Buisson<sup>1</sup>, Andre Jardim Arruda<sup>2</sup>, Renaud Jaunatre<sup>3</sup>, Soizig Le Stradic<sup>1</sup>, Isabelle Muller<sup>1,4,5</sup>, Nicole Yavercovski<sup>4</sup>, Loic Willm<sup>4</sup>, Thierry Dutoit<sup>1</sup>, François Mesléard<sup>4</sup>, Fernando A.O. Silveira<sup>2</sup>

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Plant community assembly on recently degraded or newly restored ecosystem can be described through the hierarchical filter model. Understanding the functioning of key filters (dispersal, abiotic and biotic filters) is a major prerequisite for successful restoration. The model includes a global species pool, divided in the internal species pool already present on site (i.e. seed bank) and the external species pool, which may disperse to the site (i.e. seed rain). Seed bank studies are thus carried out to identify the resilience potential on degraded sites and topsoil transfer potential efficacy. However, because of scale issues (differences between sampling methods and size of seed bank studies vs. large scale restoration) and of differences in growing conditions (greenhouse studies vs. on-site), seed bank studies can be misleading for restoration. We show examples of reference ecosystem seed bank found to be scarce and poor in target species (4 sp. on average; mainly *Brachypodium distachyon* and *Poa bulbosa*) while topsoil transfer allowed the transfer of ca. 60 species / 4 m<sup>2</sup>. Seed rain studies are complementary to seed bank studies to identify resilience issues. Sites with rare seedling establishment and virtually inexistent seed banks can be considered as requiring propagule reintroduction to promote their restoration. If seed rain studies show that some seeds are transported to these degraded sites, the restoration process should then not only focus on propagule reintroduction but mainly on germination and establishment as crucial filters.

## MICROTOPOGRAPHIC FEATURES AID IN THE ESTABLISHMENT OF COLONIZING VEGETATION FROM SOIL SEEDBANK ON RECLAMATION SITES

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Many industrial activities in forested regions require extensive disturbance or even complete removal of surface soil, which leads to severe disruption of ecosystem function. Re-establishment of herbaceous and shrub vegetation layer is often initiated by transferring salvaged forest floor material with interspersed plant propagules from a future-use site to the reclamation area. This study evaluated the role of topography and microtopographical features on early vegetation development from the propagule bank. In an operational-scale field experiment, we explored three techniques that allowed for a manipulation of micro-topography on a large south and east facing slope. Salvaged surface soils were roughened by (1) creating 60cm-deep trenches perpendicular to the slope, or by (2) placing loose soil material in large piles (ca. 7 m<sup>3</sup>), and compared to current operational procedures of a contoured site with a uniform surface. Slope aspect and micro-topographical treatments significantly affected the expression of the soil propagule bank from the salvaged forest floor material placed on the site. Placing material in piles showed the highest vegetation abundance and diversity, with low-lying areas being most conducive to plant establishment. Soil moisture was also higher in this treatment, likely driven by higher infiltration rate of loosely placed material, as well as surface roughness and increased shade which reduced vapor pressure deficit. Lastly, piling created most desirable growing conditions for forest species, as many of them were uniquely found in this treatment. These results indicate the importance of microtopography for the reestablishment of a diverse vegetation layer on sites with previously removed topsoil.

## **SPECIES COMPOSITION OF SOIL SEED BANK AND RECRUITMENT WITHIN REVEGETATION SITES: A MEASURE OF ECOLOGICAL RESTORATION POTENTIAL**

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In an intact ecosystem, the seed bank functions as a reservoir for recruitment and is presumed to be an important component in ongoing and future vegetation dynamics. In restored sites, the seed bank is likely to have occurrences of seeds from the degraded vegetation type whose substitution was the purpose of the intervention. In the present study we sampled the soil seed bank in a chronosequence of restoration sites in three sub-catchment areas in SE Australia, using degraded sites and intact sites as controls. We propose, as an index of restoration value of the seed bank, to use the ratio of seeds of exotic to native species, the ratio of exotic to preferred species or the ratio of non-preferred to preferred species. At selected sites, we also sampled the seed rain which was numerically dominated by two invasive grass species. This suggests that restored sites are subject to a considerable “pressure” from undesired propagules, and that this would be worst when there are repeated disturbances.

## **THE IMPORTANCE OF THE UNSEEN – CAN SOIL SEED BANK CONTRIBUTE TO GRASSLAND RESTORATION? TWO ESTONIAN EXAMPLES – ALVAR AND FLOODED MEADOWS**

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Numerous studies demonstrate depletion of grassland species in soil seed banks (SSB) both in cases of intensified management or abandonment of semi-natural grasslands. Therefore, the propagules from SSB are unlikely to support grassland restoration. We studied the SSB on two formerly extensively managed grassland systems in Estonia – flooded meadows with natural hydrological regime and unaltered soil fertility, and alvar grasslands. Neither of the grasslands had been subjected to intensive management, but were in parts overgrown by woody vegetation after abandonment. We looked at overall and specialist species richness of both systems in managed, 25-yr and 50-yr abandoned grasslands in above-ground vegetation and the SSB. The richness in vegetation decreased within time since abandonment in both grasslands, as did the share of typical alvar or flooded meadows species. The SSB richness responded less sharply to time since abandonment and on flooded meadows depended strongly on community type. However, the share of typical alvar or flooded meadow species remained relatively high in both systems even in abandoned sites.

The results indicate that the restoration potential of SSB in abandoned grasslands can be higher than that seen in the case of grasslands subjected to intensive management.

## MANAGEMENT HISTORY AFFECTS GRASSLAND SEED BANK BUILD-UP

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Disturbance in the form of different management regimes affects established vegetation, but how the same management affects the corresponding seed banks is poorly understood. We used the seedling emergence method (germination of seeds from concentrated soil samples in a greenroom) to investigate how present and previous management intensity impacts the dynamics of established vegetation and corresponding seed bank in six semi-natural grasslands (three pastures and three road verges) in W Norway. We quantified the site-specific management intensity by incorporating intensity, timing and duration of grazing and mowing into a single value. The increased management intensity reduced seed bank species richness but increased seedling density and the fraction of species with a persistent seed bank. Higher intensity also increased the components' floristic similarity, probably through formation of gaps where seeds may germinate. Moreover, the seed bank responded in parallel with the established vegetation to underlying environmental variables as well as to management intensity. Management intensity hence impacted directly on many aspects of seed bank-established vegetation relationships, and controlled established vegetation partly through seed bank dynamics involving both temporal and spatial dispersal.

## SEED BANK DYNAMICS DURING SEVEN YEARS OF EXPERIMENTAL GRASSLAND RESTORATION

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Seed banks play an important functional role in the continuous regeneration of many grassland plant species. In contrast, seedling establishment of undesirable species, whose seeds may also be present in the soil seed bank, has the potential to negatively affect such regeneration. Seed bank dynamics during grassland restoration are thus of general interest to restoration ecologists working with this type of ecosystem. Using mixed-modelling and ordination approaches, we investigated seed bank dynamics of both sown and unsown species during 7 years in a grassland restoration experiment. Experimental treatments involving different types of pre-sowing cultivation and the sowing of seed mixtures of different levels of species richness were arranged within a randomized block design at representative sites in three regions in the south of England. Here we present results from this investigation, showing amongst others that the use of species-rich mixtures results in faster accumulation of target forb species in the soil seed bank.

## IS THE PROMISING VEGETATION RECOVERY IN CALCAREOUS SAND GRASSLANDS REFLECTED BY THE SEED BANKS?

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Spontaneous recovery processes are increasingly involved in grassland restoration actions, because they offer a cost-effective solution compared to technical reclamation methods. Studying old-fields with different age and target calcareous sand grasslands, using the chronosequence method, we aimed at to answer the following questions: (i) How fast and successful is spontaneous succession in the recovery of calcareous sand grassland vegetation in old-fields? (iii) Which species contribute to the seed banks of old-fields and target grasslands? The cover of vascular plants was recorded in early May and late June 2012. The thin-layer seedling emergence method was used in seed bank analyses. We found that spontaneous succession is a vital option in grassland recovery because the majority of the species can be recovered in the first 10–20 years. In open grasslands only sporadic seed banks were detected, while several hygrophytes had dense seed banks in closed grasslands (*Holoschoenus romanus* and *Juncus articulatus*). Most target species possessed at most sporadic seed banks. The development of seed banks in old-fields progressed towards to that of target grasslands and the proportion of ruderal species decreased with time (e.g. *Conyza canadensis* or *Ambrosia artemisiifolia*). Our results indicated that the success of grassland recovery can be strongly influenced by seed dispersal, and is the most promising when target species can immigrate at the very beginning of the succession.

# SESSION 25 – WISE USE OF PLANTS

Chair: Johannes Kollmann

Environmental degradation calls for restoring biodiversity and ecosystem functions, while there is considerable controversy about the plant material to be used. Which advantages do regionally sourced materials (individual plants, hay or threshed material, seeds) offer over non-locally sourced seeds, or over selectively bred seed material, such as is contained in many standard commercial seed mixtures? The question gains complexity by fragmentation, intensification, invasion by exotic plants into landscapes from which plant materials are sourced, and into which they are transferred upon restoration and ecosystem creation. We welcome both conceptual papers and original field research from dry and wet ecosystems, from non-woody and woody species and vegetation types.

SESSION 25-01 – WISE USE OF PLANTS

## THE ROLE OF NURSE PLANTS AS DRIVERS OF COMMUNITY ASSEMBLY AND ECOSYSTEMS FUNCTIONS IN METALLIFEROUS MINE TAILINGS

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Metalliferous mining industry creates waste tailings that act as micro-deserts controlled by severe abiotic stress due to high toxicity, physical instability and scant soil and water resources. These conditions hinder both the biological recolonization process and restoration activities. Facilitation, the mechanism by which an organism (beneficiary species) profits from the activity or presence of another organism (nurse), is a major force shaping plant communities under high stress conditions. However, the role of facilitation as driver of community assembly and ecosystem functions has been rarely reported and hardly used in restoration of mining areas within Natura2000 sites. We surveyed the existence of nurse plants and assessed their role as promoters of basic ecosystem functions such as productivity and nutrient cycling in mine tailings from SE Spain that were abandoned three decades ago. We hypothesised that plant facilitation drives ecosystem stress reduction by ameliorating the microclimatic conditions and supplying organic resources into waste tailings. This mechanism shapes phylogenetically and functionally more diverse communities by niche complementarity. Thirteen plant species were identified as nurses with contrasted ability to create patches of high diversity and promote soil fertility and nutrient cycling. Some nurses only promoted plant establishment of beneficiary species whereas other nurses significantly improved soil quality too. Functional traits of nurses help explaining their nursing quality and open the door to a more effective plant selection in phytostabilization programs, in order to get an effective restoration that trigger ecosystem functions beyond the survival of planted species.

## PRESERVING FUNCTIONAL TRAITS AND TRAIT VARIATION IN EX SITU CONSERVATION PROGRAMS: LESSONS FROM BOTANIC GARDEN COLLECTIONS

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The preservation of endangered species ex situ in botanic gardens and gene banks has become an important pillar of species conservation and restoration programs. However, previous studies have shown that particularly cultivation of plants for many generations can decrease the genetic diversity and also the fitness of the ex situ collection due to the effects of inbreeding and genetic drift. Moreover, changes in selection regime may result in shifts of important functional traits and potentially also reduce trait variability. Functional traits and their heritable variation have not only been invoked as a pivotal feature of a population to adapt to rapidly changing environmental conditions (evolutionary potential), but also as an important element for the proper functioning of the whole ecosystem. To investigate whether ex situ collections can preserve functional traits and the evolutionary potential of the original wild population, we compared the functional traits and the trait variation of 18 plant species conserved as collections in the Botanic Garden Meise, Belgium with their original wild source populations. To directly test the plants' ability to cope with environmental changes, we additionally compared the plants' response to drought stress. Our experiment will provide crucial information for the improvement of ex situ conservation in order to provide best-suited plant material for restoration programs.

## DOES INTRASPECIFIC GENETIC STRUCTURE SUPPORT SEED TRANSFER ZONES CURRENTLY USED IN RESTORATION?

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Ecological restoration has become successful in preserving natural resources in recent years, and it often includes translocation of plants from a source population to another site. A major factor for the long-term success of such translocations is to take into consideration local adaptation and genetic diversity. To conserve intraspecific genetic structure, which frequently is considered to be geographically correlated, guidelines have been proposed and positively tested, for example in Germany. The German guidelines identify 22 seed transfer zones (STZ) within which plants may be translocated. However, the STZs are not necessarily in accordance with traditionally postulated corridors for plant migration such as large river systems originating in the Alps. We conducted a pilot study using microsatellite data for 12 loci in 264 individuals derived from 12 populations of *Buphthalmum salicifolium*, a common pre-alpine species of calcareous grasslands. Individuals of a commercially produced cultivar were included in the analysis because cultivars might be used in some restoration projects. The results show that genetic structure of the wild populations does not reflect connectivity along river corridors, but rather differences among STZs. However, we identified even smaller scale geographic differentiation. The cultivar plants showed the highest overall divergence underlining the risk of introducing potentially maladapted genotypes. Ongoing projects investigate roughly ten other species of calcareous grasslands, with a focus on the selective filters possibly introduced by restoration activities. Our results call for more comprehensive population genetic studies of plant species used for restoration, and the need to modify current best-practice guidelines.

## DIFFERENTIATION AMONG POPULATIONS OF *BRACHYPODIUM RETUSUM*: CONSEQUENCES FOR THE RESTORATION OF MEDITERRANEAN STEPPES

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The ecological restoration of Mediterranean steppes is a slow process because several of their keystone species are poor colonizers. In the plain of “La Crau” (South-Eastern France), *Brachypodium retusum* (Pers.) P.Beauv. is such a key species. Although dominant in the traditionally grazed steppe system, its seedling recruitment is very low. In order to evaluate the efficiency of reintroduction by sowing, population differentiation and adaptation were tested in lab and common garden experiments. Sixteen populations were collected at a regional scale. Collection sites differ in grazing intensity, climate and soil conditions. *B. retusum* occurs on two distinct soil types, calcareous and base-poor red Mediterranean soils. Structured sampling including close-by pairs (10 km) of these soil types collected at different distances was used to analyse spatial structure of population differentiation. Different humidity levels were also applied in a germination experiment testing for adaptation to this factor. Significant differences between populations were found in all studied traits. Soil type had a significant effect on germination but not on growth. Site of origin explained population differentiation better than soil of origin, suggesting an influence of climate. However, adaptation to humidity was weak in germination tests. Surprisingly high germination and seedling survival indicated that restoration by sowing may be successful under favourable recruitment conditions.

## TO SOW OR NOT TO SOW – POTENTIAL GENETIC CONSEQUENCES OF USING SEED MIXES FOR RESTORATION

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Commercially produced seed mixes are often used in grassland restoration. However, the genetic diversity and consequent fitness of plants originating from seed mixes are rarely evaluated. In a fragmented agricultural landscape in Switzerland, we examined the genetic diversity and fitness of naturally occurring populations of *Lychnis flos-cuculi* to that of populations restored by using commercial seeds, which were of local origin, but had been propagated over a number of generations in the seed company. Second, we carried out experiments to assess the effect of local adaptation on fitness. Third, in a climate chamber experiment we examined the fitness of plants originating from sown and natural populations of *L. flos-cuculi* as well as from several seed suppliers in response to soil moisture and nutrient content. Restored populations of *L. flos-cuculi* were more inbred and had a different genetic composition compared to natural populations. However, higher inbreeding had no apparent associations with the fitness of restored populations. There was also no clear evidence that plants from natural populations were better adapted to local environment than plants from sown populations or from seed suppliers. Nevertheless, in a climate chamber experiment, the plants of natural origin invested more into generative reproduction and tended to flower earlier than plants originating from sown populations or from seed suppliers. Our findings indicate that the use of commercial seed mixes can have both genetic and fitness consequences, which may potentially affect short- and long-term restoration success.

## PLANT GENOTYPE EFFECT ON HERBIVORE PERFORMANCE: A META-ANALYSIS

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In plant conservation and ecosystem restoration, plants are frequently translocated to ensure or enhance plant survival and performance. Effects of plant translocation on other organisms are often neglected. In the practical context, the magnitude of such effects is important: while an effect size of e.g. 5% likely does not alter ecosystem functioning, effects of tens or hundreds% might have crucial importance. However, the general magnitude of plant ecotype effect on interacting organisms is unknown. We focused on the intraspecific variation of plants in interaction with herbivores. We gathered data from 56 studies describing 43 herbivore species feeding on 39 plant species. Within each study, plant and herbivore species, we calculated the difference in plant genotype (ecotype) effect on herbivore fitness as a ratio of the herbivore fitness on plant genotype one vs. genotype two. If this difference was equal to one, herbivores had the same fitness on both plant genotypes. If the difference was e.g. two, herbivores had twice higher fitness on one plant genotype than on the other one. Over all species and genotypes, the mean of the difference in plant genotype effect on herbivore fitness was two. However, the data were strongly skewed. While median was 1.3, 10% of the differences in herbivore fitness between plant genotypes was higher than 3.6. Plant ecotype identity affects herbivore fitness and the effect sizes can be quite large. The effects size increases, moreover, with geographical distance between plant origins. In restoration projects, the origin of introduced plant ecotypes might have crucial importance for performance of interacting organisms and thus must not be neglected.

## ECOLOGICAL RESTORATION POLICY AND A NATIVE SEED SOLUTION: CAN WE SEED THE FUTURE OF EUROPE?

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Over the last few decades, various strategies have been implemented globally and nationally to meet the latest biodiversity and conservation targets, such as the Strategic Plan for Biodiversity 2011–2020 (CBD), the Global Strategy for Plant Conservation (CBD), and the EU Biodiversity Strategy (European Commission). However, in most cases progress to meet these targets has been slow and/or difficult to measure. To meet current restoration demands in Europe, large-scale production of wild seed is needed, yet few policies exist to regulate native seed use and production. With the absence of native seed quality protocols, policies, and training for users, restoration efforts are challenging and often use non-native plant species. This presentation will highlight the current policies for native seed production in Europe discussing the current progress, application to native seeds, and overcoming these challenges by bringing policy into practice. In addition, it will introduce a bottom-up approach to addressing policy and certification issues applicable to native seed use. This project is part of the NATive Seed Science, TEchnology and Conservation (NASSTEC) network, an FP7 Marie-Curie ITN which is a partnership between industry, academia and research institutions that uses a multifaceted approach to promote the development of a sustainable and a dynamic European native seed industry, and to strengthen native seed science and conservation needs.



## NOT TO HARM: SEED HARVESTING IN WILD POPULATIONS

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The growing number of restoration projects worldwide leads to increasing demand for seeds of native species. The seeds are often collected in the wild. The source populations might be negatively affected by removing part of the propagules. To minimize the harm, instructions on seed harvests commonly contain maximum percentages of seeds which can be collected from a population. However, the limits are mostly based on expert opinions, and rarely supported by data. In this study, we focused on the effect of seed harvest on population dynamics in almost 360 species from wide taxonomic range and of various growth forms. We used data from a database of plant population matrices, COMPADRE. Each matrix describes population dynamics of one species and is based on data collected in a field study, mostly over multiple years and populations. We simulated seed harvesting as reducing the part of the matrix describing seed production, and calculated sensitivity of the population dynamics to the seed harvesting. We related the sensitivity to the life history traits of the species. Seed harvest has the largest impact in short living species, especially annuals with transient seed banks. With increasing life span and seed bank longevity, the sensitivity of plant populations to seed harvest decreases. In long living species or species with permanent seed bank, the impact of seed harvest is small. In extreme cases, like long living trees, especially with persistent seed bank, the impact of seed harvest is almost zero. We used the life history traits, specifically longevity and seed bank persistence, to create a decision tree, which will help policy makers and practitioners to set limits of seed harvest specifically for each individual species.

## GENETIC VARIANCE ANALYSIS OF *MISCANTHUS SINENSIS* AND *PHRAGMITES AUSTRALIS* TO APPLY REGIONAL SEED FOR RESTORATION IN KOREA

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Many Korean ecosystems require restoration because of drastic development, urbanization and devastated ecosystems. But, in fact, South Korea is a very small country. So many Koreans are in doubt about the necessity of seed transfer zones in Korea. In recent years, Korea has made a lot of restoration utilizing *Phragmites* and *Miscanthus* without considering seed zones. In this study, we identified the variation in phylogenetic relationship of *Miscanthus sinensis* or *Phragmites australis* by locations in Korea. Chloroplast DNA atpF-H, psbA-trnH interspace region, matK were used as a molecular marker to determine the phylogenetic relationship in 10 different regions. We performed the molecular phylogenetic analysis with 10 chloroplast DNAs from each location using Kimura 2-parameter. The analysis of *Miscanthus* showed that all atpF-H genes were exactly matched, except for the "Oseo mountain" accession. In contrast to *Miscanthus*, the atpF-H genes from *Phragmites* showed more variation. A total of 7 locations revealed the variation of chloroplast gene. According to the phylogenetic tree in *Phragmites*, the genetic distance of 2 of 10 samples in six locations and 3 of 10 in one location range from 0.160 to 0.181. The combined analysis and further analysis will be discussed. This subject is supported by Korea Ministry of Environment(MOE) as "Advanced Industrial Technology Development" (2014000130004)

## NASSTEC: AN EUROPEAN PROJECT TO MAKE SEED-BASED RESTORATION EFFORTS MORE EFFECTIVE

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The European NASSTEC (NAtive Seed Science, TEchnology and Conservation) project is training 11 Early Stage Researchers and one Experienced Researcher in native seed science, technology, conservation and use, by integrating academic and industry to try and solve challenges in native seed production for restoration so that environmental mitigation and adaptation projects can have increased impacts. Without immediate enhancement of the capability in this specific area of biodiversity science, the native seed industry in Europe will fail to develop and to meet the native seed demand for large-scale restoration activities. NASSTEC partners include four academic institutions (James Hutton Institute, UK; Museo delle Scienze, IT; Royal Botanic Garden Kew, UK; University of Pavia, IT) and three private native seed companies (Scotia Seeds, UK; Semillas Silvestres, ES; Syngenta seeds, NL) where the research fellows are based and where they are currently working on individual research projects belonging to three different sub-programmes: A. *In situ* seed sampling, B. Seed biology characterisation, and C. Production and deployment of seeds. Furthermore, three restoration pilot projects are ongoing in three different target bio-regions: The Alpine, the Atlantic and the Mediterranean.

## A EUROPEAN TOOL TO FACILITATE KNOWLEDGE TRANSFER AMONG NATIVE SEED PRODUCERS, RESEARCHERS AND USERS

Marcello De Vitis<sup>1</sup>, Giles Laverack<sup>1</sup>, Holly Abbandonato<sup>2</sup>, Costantino Bonomi<sup>2</sup>

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Stakeholder groups in native seeds are often disconnected from each other resulting in poor availability of the right seeds for restoration. Information about the demand for seeds for restoration, which species and populations are required, what is available and the quality standards needed is often lacking. The potential to reveal problems in native seed use and to work through solutions from lab to sowing is often unfulfilled because of this disconnection, with failures in some restoration projects. To fill this gap and to encourage dialogue and knowledge exchange among stakeholder groups, the European NASSTEC (NAtive Seed Science, TEchnology and Conservation) project is currently creating a communication network among academia, producers and users, through the following steps and tools: 1) compilation of a European stakeholders network; 2) a survey for the stakeholders to reveal the technical problems in each area and the difficulties in interconnecting with the other stakeholder groups; 3) attendance and creation of events to meet different stakeholder groups and invite them to share their knowledge and ideas; 4) set up of a European online platform to facilitate the exchange of useful information and material for restoration purposes; 5) proposal of European seed zones and of European native seed certification scheme and trade association.

# SESSION 26 – DEALING WITH INVASIVE SPECIES

**Chairs: Jürgen Geist, Johannes Kollmann**

Neobiota are a major challenge to contemporary restoration. Since discovery of the Americas, human travelling and trade have accelerated rates of introduction of plant and animal species from remote countries, even continents, by several orders of magnitude, so that their number or biomass or both often exceed that of indigenous species. A fundamental debate has arisen in restoration ecology on whether to combat these species at all costs with continuously refined techniques, or whether to accept their coexistence with native species in novel species assemblages and ecosystems. In this session, we welcome conceptual works and models that aid in decision-making in post-invasion scenarios, as well as field studies on successes and failures in reducing invasive plant and animal species. We would also like to encourage studies that aim at preventing invasion in restoration and conservation areas.

## ALIEN PLANT INVASIONS ACROSS EUROPEAN WOODLANDS

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Information about the intrinsic susceptibility of habitat types to alien plant invasions is integral to risk assessment. However, little is known about the levels of alien plant invasion across European vegetation types. We used data from 246,899 plots extracted from the European Vegetation Archive and additional datasets to compare the levels of invasion across EUNIS woodland habitat types. For every plot, we assigned a EUNIS habitat type and for every species in a country, we assigned a status (alien, native) and origin (e.g. intra-European taxa, extra-European taxa). Data were extensively filtered and only well-represented EUNIS types were included in the analysis. The level of invasion was calculated as the number of alien species (neophytes) divided by the total number of species in a plot. Our first results show that softwood riparian woodlands had by far the highest level of invasion (mean = 4.9%); other riparian woodlands also reached high values (>1.3%). By comparison, coniferous forests tended to rank among the habitat types with the lowest levels of invasion. The extra-European *Impatiens parviflora*, *Prunus serotina*, and *Robinia pseudoacacia* were the most common aliens in European woodlands and had the broadest habitat niche. Our results suggest that woodlands with a high disturbance regime and nutrient flow face a higher risk to alien plant invasions.

## HEMIPARASITIC *RHINANTHUS* SPECIES CAN SUPPRESS COMPETITIVE DOMINANT *CALAMAGROSTIS EPIGEJOS* AND RESTORE SEMI-NATURAL GRASSLANDS

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Dominance of alien or native competitive plants causes competitive exclusion of subordinate species, which represents a major mechanism of biodiversity decline following land-use change. The successful competitive strategies may however be interfered with by parasitic plants. Parasitic plants may cause disproportionately more harm to the dominants, facilitate establishment of other species and consequently trigger restoration of species-rich communities. *Calamagrostis epigejos* is a vigorous clonal grass occurring in Eurasian grasslands. In recent decades, *C. epigejos* has invaded species-rich semi-natural grasslands of Central Europe, which is one of the prominent factors causing their biodiversity decline. I summarize results of a research project aiming to test the effect of the introduction of native hemiparasitic *Rhinanthus* species by seed sowing on *C. epigejos* and various vegetation types infested by it. To test the effect of the hemiparasites in a large-scale landscape context, a medium-term (3–4 years), multi-site (n = 26) before-after control-impact field experiment was established in the Czech Republic and Slovakia. *Rhinanthus* species established at most sites. A linear mixed-effect model identified a significant interaction between time and *Rhinanthus* sowing indicating a significant reduction of *C. epigejos* by *Rhinanthus* (which was mostly rather massive). *Rhinanthus* also significantly decreased vegetation density in the first years after its sowing and thus opened gaps for seedling establishment. A partial canonical correspondence analysis of the community composition change demonstrated that multiple species typical of semi-natural meadows increased following *Rhinanthus* introduction and *C. epigejos* decline.

## BARRIERS TO ECOSYSTEM RESTORATION ARISING FROM SOIL LEGACY EFFECTS AFTER CLEARING INVASIVE N-FIXING SPECIES

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The impacts of nitrogen-fixing invasive trees and shrubs, mechanisms underlying and restoration initiatives targeting these impacts, and their prioritization are well appreciated, but soil legacy effects, barriers to native species re-establishment after invader removal, and their link to restoration efforts are poorly understood. Finding a better way to deal with these legacy effects and barriers would be essential for improving the restoration of previously invaded sites. We reviewed global literature and identified nine legacy effects and associated barriers and eleven management strategies. Here we discuss appropriate strategies for combining available management strategies for the barriers in order to achieve the best restoration outcomes. Using *Acacia* invasions in South Africa as a case study, we also investigated the effects of altered soil nutrient composition and microbial communities, and secondary invaders on the germination, root and shoot growth, and root to shoot ratio of native species in cleared sites in comparison to reference pristine sites in greenhouse conditions. Competition from secondary invaders reduced root and shoot growth in cleared and their pristine reference sites whilst increasing the root to shoot ratio. We encourage the implementation of multiple successive follow-treatments in previously invaded areas, and future studies should investigate the persistence of all soil legacy effects and barriers in all species they are identified for.

## RESTORING SHRUB STEPPE LANDSCAPES IN THE FACE OF FIRE AND INVASIVE SPECIES – PRIORITIZING USING RESISTANCE AND RESILIENCE

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*Artemisia*-grasslands are one of the most threatened ecosystems in North America. Invasive annual grasses and altered fire regimes have led to losses of fire sensitive shrubs on which many wildlife species depend for their survival. The greater sage-grouse is a landscape bird whose survival is dependent on minimally fragmented *Artemisia*-grasslands. Invasive annual grasses, many in the genus *Bromus*, have reduced fire return intervals and increased fire sizes leaving large tracts of land without *Artemisia* and potentially crossing ecological thresholds, making recovery difficult. Restoration, in combination with conservation, has been proposed to restore *Artemisia*-grassland ecosystems, but landscapes must be prioritized for actions to sustain greater sage-grouse populations. A matrix using plant community resistance to invasive annual grasses and resilience from disturbances in combination with landscape cover of *Artemisia* (assessed using Landfire satellite land cover maps) is being used to prioritize management across the *Artemisia* biome. Resistance and resilience are correlated positively with soil temperature and soil moisture regimes. After fires, sites that are resistant to invasion by annual *Bromus* require two or more perennial tussock grasses per square meter and 20% foliar cover of perennial grasses. Priority areas of conservation (PACs) for greater sage-grouse are the initial landscape for potential actions. Within PACs, land areas of resistance and resilience are mapped and management specific to those areas are proposed. This approach is currently being implemented within this biome to maintain wildlife and land uses. Monitoring and adaptive management will guide future restoration.

## A COMPARISON OF TWO ERADICATION METHODS TO CONTROL *LUPINUS NOOTKATENSIS* SPREAD IN ICELAND

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*Lupinus nootkatensis* was introduced to Iceland for revegetation and afforestation purposes in 1945. It is now classified as an invasive species and is an example of a good intention that goes wrong, as there is now a growing need for controlling it. In 2010, an experiment was established in Stykkishólmur, W-Iceland, to compare the impact of two eradication methods on lupine and other vegetation. The experiment included three treatments; cutting, herbicide (glyphosate) application and untreated lupine, a total of 15 plots (100 m<sup>2</sup>) in five replicates. The treatments were applied annually and vegetation measured after one (2011) and five years (2015). In 2015, the cover and density of flowering lupine were significantly lower in treated than untreated plots, but species richness was significantly higher in the treated plots in 2015. Species composition of treated plots changed greatly from 2011–2015 while changes in untreated plots were small and more erratic. The cut plots had the highest species richness, the greatest cover of grasses and herbs other than lupine, and the least cover and density of lupine. The herbicide plots had higher proportion of bare ground and much less grass cover than the cut plots. Our results suggest that annual cutting gives better results than application of herbicide as it interferes less with other vegetation. It should, however, be emphasised that the control of lupine requires a long-term commitment.

## MICROWAVE SOIL HEATING FOR CONTROLLING INVASIVE PLANT SPECIES GERMINATION

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Several methods of invasive plant eradication are available (manual and mechanical control like plant uprooting, chemical control or biological control, etc.) but examples of successful long-term eradications are rare. This can be partly explained by the fact that eradication methods target only the adult stage, and do not take into account the development capacities from a very important propagules bank. New methods thus have to be implemented. Microwave radiation causes dielectric heating of moist material and enables us to rapidly reach temperatures needed for loss of seed viability (60–80 °C range). We tested the effect of different combination of powers (2, 4, 6 kW) and durations (2, 4, 8 min) on 3 target invasive plant species (*Fallopia japonica*, *Datura stramonium*, *Solidago gigantea*). We also evaluated the effect of soil humidity (10, 20, 30%) and seed depth (2, 12 cm) on the efficacy of the microwave treatment on germination capacity. The most efficient treatments were: 2 kW<sub>g</sub> min, 4 kW 4 min, 6 kW 2 min and 6 kW 4 min (4 kW 8 min and 6 kW 8 min were not tested for technical reasons), but they did not allow to eradicate all seeds. Their efficiency decreased with increasing soil humidity. In some cases, efficiency also decreased with depth. *Solidago gigantea* was the most sensitive species, probably due to the small size of its seeds. These first results are encouraging and experiments are on-going to determine the characteristics of the microwave that will be used in the field.

## EFFECT OF COMMON MILKWEED (*ASCLEPIAS SYRIACA*) ON SANDY FLORA

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Common milkweed (*Asclepias syriaca*) is a “super species” forming stable novel ecosystems, and invading extended areas in Europe. Former studies reported no effects of milkweed on the native flora. However, it is unlikely that the effects of this competitor species with effective propagation remain neutral to local flora and vegetation. To explore the potential effect of milkweed on the natural sandy flora, we studied the vegetation of seven sandy old-fields invaded by common milkweed, and to identify the most sensitive species groups we performed trait-based analyses. We detected no effect of common milkweed on total species richness; however, we revealed a negative effect on the cover of natural grassland species. The negative effect of common milkweed was the most pronounced on the cover of species with low specific leaf area, low seed weight and low clonal spreading ability. However, species with high competitive ability could maintain their cover in spite of invasion of common milkweed. Our results suggest that milkweed can delay the colonisation of species of natural flora and hamper old-field succession towards natural-like grasslands. Therefore, habitats invaded by milkweed are such undesirable novel ecosystems which can have significant negative impacts on the natural flora. Therefore, to ensure the persistence of threatened species of sandy grasslands, management of milkweed is needed.

## INVASIVE SPECIES SURVEY AND LOCAL USES IN NAKHON RATCHASIMA PROVINCE, THAILAND

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Invasive alien species can cause ecological and economic loss in many parts of the world. Nakhon Ratchasima is the second largest province of Thailand, situated in the Northeast of the country, covering an area of 20,493 km<sup>2</sup>. The aim of this study was to determine invasive species spatial distribution in this province. From February 2015 to February 2016, we conducted many road surveys along the main and secondary roads into villages, covering 2,250 km, and visited the main rivers, canals and water reservoirs in the province. The results found 88 invasive alien species including 36 plants, 32 insects, 13 fishes, 3 molluscs, 3 birds and 1 reptile. The most widespread plants alongside the roads were *Leucaena leucocephala* (Lam.) de Wit, *Chromolaena odorata* (L.) R.M. King & H. Rob., *Imperata cylindrica* (L.) P. Beauv., *Pennisetum polystachion* (L.) Schult and *Panicum maximum* Jacq., whereas the most widespread species in water was *Oreochromis niloticus* (Linnaeus). Local people perceived invasive species as minor problems because they use many of these species for food, medicine, handicrafts, clothes, household materials and fuel.

## EVALUATION OF CONTROL METHODS FOR INVASIVE SPECIES IN PEATLANDS

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Common reed (*Phragmites australis*, the non-native Eurasian phenotype) and broad-leaf cattail (*Typha latifolia*, a native plant of North America) are often seen in bogs once the extraction activities have ceased. They are considered invasive and undesirable plants in bogs. Therefore, plant invasions could modify the habitat structure and reduce carbon sequestration in peatlands. Common reed and cattail colonies recently increased in size and amount in two bogs located in eastern Canada (province of Quebec) on the south shore of St. Lawrence River. The main goal of this project is to test methods to control invasion of peatlands by these invasive species. Different control methods such as repeated cutting of stems, tarping and revegetation have been tested on cattail or reed separately, in Bois-des-Bel (a restored site) and Saint-Alexandre-de-Kamouraska (an unrestored site). The efficiency of each method was estimated by comparing the density of stems and the biomass of cattail or reed produced at the end of the growing season. Repeated cutting (three times per season) decreased cattail stems density by 77% and biomass by 88% compared to sectors where no control was performed. Field observations suggest that combining tarping and revegetation by planting exotic willow species could rapidly create a dense canopy, which could inhibit the stems re-growth and biomass production of reed. This project is addressing a new perspective of biological invasion in North American peatland ecosystem. It contributes to developing technical and operational expertise about invasive plant control, based on an experimental approach.

# SESSION 27 – FACILITATING RESTORATION

**Chairs: Saija Kuusela, Santtu Kareksela**

The 15% restoration target is among the Aichi Biodiversity Targets, mentioned in the EU Strategic Plan for Biodiversity 2011–2020 and ratified into several national biodiversity strategies. However, restoration at this scale is not sustainable without cooperation between restoration science and practice, landowners and other stakeholders, and policy makers, and it is not efficient without systematic planning and spatial conservation prioritization methodologies. In this session we will discuss theoretical as well as practical aspects of (1) spatial prioritization of conservation and restoration measures, (2) the perception of restoration and conservation by land owners and other important stakeholders, (3) how to attract stakeholders towards achieving restoration goals and to integrate them in planning and execution, and (4) how to inform and guide policy decisions.

SESSION 27-01 – FACILITATING RESTORATION

## UTILITARIAN AND NON-UTILITARIAN VALUATION OF NATURE AND NATURAL RESOURCES: A GAME-THEORETICAL APPROACH OF VALUATION

Sjaak Swart, Jorien Zevenberg

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Garret Hardin argued by the metaphor of the “The Tragedy of the commons” that free utilization and access to natural resources inevitably leads to environmental overexploitation. This is often analysed as a prisoner’s dilemma, based on the game-theoretical notion that an actor will maximize his or her own payoff, given the individualistic utilitarian rationality of others. However, people do not act on utilitarian considerations alone and non-utilitarian considerations may also lie behind one’s decision to reduce the utilization of natural resources. This paper develops a game-theoretical approach to nature and natural resources by making use of a Cobb-Douglas utility function that takes into account both utilitarian and non-utilitarian considerations of an actor to derive his or her so-called value achievement. It is shown that this may turn the prisoner’s dilemma dynamics into assurance game dynamics. Accordingly, we turned this 2-persons game into a multiple persons game. A simulation shows that if a sufficient number of people - depending on the model parameters describing value-orientations - maintain a non-utilitarian attitude, the lock-in dynamics of the prisoner’s dilemma can be avoided and a much higher value achievement will result. The model was empirically confirmed by a survey among 164 life sciences and biology students assessing their willingness for voluntary use restrictions in a hypothetical restoration project. Based on these results, it is argued that public policies and discussions that also emphasize non-utilitarian considerations are an important strategy in conservation and restoration projects that aim for participation of lay people.



## **BUILDING BETTER RESEARCHER PRACTITIONER PARTNERSHIPS: RESTORATION STORIES FROM LOCAL GOVERNMENT IN DURBAN, SOUTH AFRICA**

Errol Douwes<sup>1,2</sup>, Debra Roberts<sup>1,2</sup>

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Anthropogenic impacts, including climate change and rapid urbanisation, are driving global scale transformations with as-yet unknown outcomes. The rate and extent of such change highlights the growing importance of ecological restoration as a tool in ensuring increased sustainability. There is a general understanding that ecological restoration involves practical field work, collection and collation of experimental field data, and reporting on the outcomes of the subsequent analyses. While this may be the narrative recorded in much of the published literature, there is an equally significant but unreported body of practitioner knowledge that has not adequately influenced the restoration debate. This is only in part due to the resource limitations that prevent practitioners from publishing regularly. Arguably, the insufficient knowledge-sharing collaborations between scientists and practitioners, are of a higher priority. Undoubtedly, this issue will be remedied, in line with moves to enhance co-design and co-production opportunities. However, the inadequate focus on the practical application, and on understanding of the opportunities and challenges, must be addressed through improved documentation of learnings. The knowledge development and support opportunities, resulting from a formal research partnership between a local university, and Durban's local government are discussed here. The advantages for the researchers and practitioners, as are already forthcoming, have contributed to new protocols for smarter collaboration and on-the-ground implementation of ecological restoration. In addition, the learnings have helped to drive the development of new local-level resilience, sustainability and adaptation strategies for Durban.

## **INTEGRATING LANDOWNERS' PERCEPTIONS INTO PRIORITIZATION OF VALUABLE AREAS - IMPLICATIONS FOR FOREST CONSERVATION MANAGEMENT**

Riikka Paloniemi<sup>1</sup>, Teppo Hujala<sup>2</sup>, Salla Rantala<sup>1</sup>, Annika Harlio<sup>3</sup>, Anna Salomaa<sup>3</sup>, Eeva Primmer<sup>1</sup>, Sari Pynnönen<sup>4</sup>, Anni Arponen<sup>3</sup>

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Innovative national solutions and particularly the integration of private landowners are essential in order to achieve the aim to restore 15% of degraded land globally. In order to achieve significant conservation benefits out of such large scale efforts, it is relevant to optimize conservation efforts spatially. In addition, in order to improve the legitimacy of conservation, it is relevant to pay special attention to voluntariness. In the study, we tested empirically the possibilities to improve landscape-level targeting of conservation in voluntary biodiversity policy by integrating landowner perceptions with ecological prioritization. We used material from a landowner survey, ecological datasets and focus group discussions and analysed how forest owners perceive conservation efforts, how combining the perceptions with ecological data in zonation prioritization affects the outcomes of conservation targeting at the landscape level, and whether multi-actor collaboration can improve the application of prioritization and thus support conservation in practice. In our analysis, the integration of ecological and social knowledge moderately changed the ecologically optimized prioritization outcome. The results also suggest that multi-actor collaboration and dialogue can further improve the legitimacy and effectiveness of prioritization.

## PRIORITIZATION AND IMPLEMENTATION OF THE 15% RESTORATION TARGET IN SPAIN

Jordi Cortina

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Achieving the 15% restoration target in Spain by 2020 may not be feasible under current socio-economic conditions. Yet, promoting large-scale ecological restoration is needed to counterbalance current and historic ecosystem degradation, mitigate climate change and adapt to its consequences, explore opportunities for growth and employment, and reconnect society and nature. However, the implementation of the 15% target faces the lack of detailed information on the current status of biodiversity and ecosystem services, the costs of restoration actions and a strong conceptual framework to define priority areas for restoration and identify achievable targets. In addition, a strategic plan for ecological restoration in Spain must take into account ecological heterogeneity and political organization into Autonomous Regions with full competence in environmental issues. The Ministry of Agriculture, Food and Environment will present the National Strategy on Green Infrastructure, Connectivity and Ecological Restoration by the end of 2016. This initiative is coordinated by the Spanish Council for Scientific Research and involves ca. 40 experts from major academic organizations, NGO's, public administrations and the private sector. Current status of the strategy concerning ecological restoration and the restoration prioritization framework will be discussed.

## HUMAN HEALTH AND ECOLOGICAL RESTORATION: A LEGAL PERSPECTIVE

Jing Zhang, An Cliquet

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Increasing evidence shows a positive link between biodiversity and human health. Scientific findings also demonstrate that ecological degradation could lead to negative impacts on human health. As biodiversity is degrading at an unprecedented rate, it therefore imposes serious threats to human health. Ecological restoration can thus contribute to maintaining and improving human health. The topic of biodiversity and human health has only been studied recently, mostly by natural scientists. This paper will analyse the relationship between ecological restoration and human health from a legal perspective from two angles. A first angle is to what extent international and European biodiversity law already pays attention to the conservation and restoration of biodiversity, in relation to human health. A second angle is the human rights perspective. The right to health has been indirectly recognized in international human rights conventions. The paper will examine some cases from the European Court of Human Rights, in which it was established that the right to health had been infringed because of the deterioration of the natural environment. Based on this legal analysis, we will assess to what extent human health is or can be used as an additional argument for ecological restoration. The paper will conclude that the right to health should and can be used as an argument for ecological restoration, but need the collaboration of natural scientists and policy and law makers.

## SUEING YOUR GOVERNMENT TO REACH ECOLOGICAL RESTORATION TARGETS: UTOPIA OR REALITY?

An Cliquet

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In several countries environmental NGOs started climate change litigation, asking the court to urge the government to increase their efforts to mitigate climate change. The purpose of this paper is to examine if similar litigation would be feasible for ecological restoration. Most international and EU biodiversity laws include obligations to restore degraded habitats and species. Concrete targets have been set, including the commitment in the Aichi targets to restore 15% of degraded ecosystems worldwide, and a similar commitment in the EU Biodiversity Strategy. Midterm scientific assessments however show that these targets are far from being met. Could a legal claim for ecological restoration stand any chance of success? Similarities and differences with the climate litigation cases will be analysed. Possible legal grounds for a restoration case will be examined. A first ground is the scientific knowledge on the importance of ecological restoration. A second ground is the international legal obligations and commitments on restoration: are these binding and concrete enough so that an individual or NGO can base a claim on them? A third ground is relying on human rights, as recent scientific findings point to the negative effects of biodiversity loss on human health. A final ground is a general duty to care for the government. Could for example an NGO demand that a government restores the coral reef as it protects the population against flooding caused by tsunamis?

## INTERNATIONAL NETWORK FOR SEED-BASED RESTORATION (INSR)

Nancy Shaw<sup>1</sup>, Stephanie Frischie<sup>2</sup>, Kingsley Dixon<sup>3</sup>, Rob Fiegenger<sup>4</sup>, Olga Kildisheva<sup>5</sup>, Simone Pedrini<sup>3</sup>

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The International Network for Seed-based Restoration (INSR), a new Section of the Society for Ecological Restoration, seeks members from the international SER community who will raise the profile of seed-based needs for ecosystem restoration. Ecological restoration is a growing sector with costs exceeding a trillion dollars annually and seed collection and cultivation industries as important components. Thus the need to develop standards for native plant seed collection, production, testing, regulation and use is critical. INSR members include professionals, scientists, students, and representatives of industry, government and non-governmental organizations. Major goals are to: (1) advance public education, policy, and awareness of the global need for native plant seed research, conservation and use; (2) sponsor a forum for interchange of new ideas, approaches, data developed and lessons learned relevant to planning, policy and science regarding native seed ecology, technology and restoration; (3) foster collaboration to develop standards for native plant seed testing and regulation; and (4) serve as an emergency expert panel to address germplasm biodiversity, conservation, seed farming, and restoration issues. To accomplish these goals, INSR will sponsor conferences, workshops, field trips 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.

## RESTORATION OF SEMI-NATURAL GRASSLANDS IN LATVIA: EXPERIENCES AND CONSTRAINTS

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<sup>2</sup>The Latvian Museum of Natural History, Riga, LV

The area of semi-natural grasslands is 47,500 ha in Latvia. Half of it is presently deteriorating, the other half is managed under the Rural Development Programme (RDP). Only 15% of it is in a favourable conservation status. The lack of ecological knowledge on biodiversity management has been one of the main reasons besides socio-economic situation. To tackle this problem, the project “National Conservation and Management Programme for Natura2000 sites in Latvia” was launched in 2012. One of the main aims was to prepare restoration and management guidelines. It was an open process involving experts, managers and governmental institutions. The guidelines are available online and the book will be published at the end of 2016. In the frame of synergistic cooperation with the Ministry of Agriculture, a compulsory training was introduced in 2016 for farmers who receive the RDP support. The book of guidelines will be an obligatory textbook. The guidelines are partly integrated in the prescriptions of agri-environmental measures. Synergy with the land marginalization research project of the University of Latvia resulted in the evaluation of the restoration perspective of EU grasslands in regions with contrasting marginalization. Marginal regions were the most important for conservation of EU grasslands. Nevertheless, not one restoration project has been carried out there. On the other hand, conservation of several EU grassland types relies strongly on Riga’s suburban area and non-marginal regions. None of these habitat types has been a subject for restoration projects in these regions. The research was supported by the Latvian Council of Science (project No. 514/2012) and by the LIFE+ project LIFE11 NAT/LV/000371.

## USING OF SOCIO-ECOLOGICAL SYSTEM FOR BETTER UNDERSTANDING AND IMPROVING OF PUBLIC GOODS/ECOSYSTEM SERVICES: PEGASUS CASE STUDIES IN THE CZECH REPUBLIC

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Pegasus is a 3year, European Commission-funded project designed to explore new and improved means of achieving environmental and social benefits from agriculture and forestry. It is gathering experience from national and local studies from ten countries. The findings should be relevant to the European rural development policies after 2020. The research consisted of: (1) Identification of the key public goods and ecosystem services “assets” within the case study area (desk analytical research); (2) Determination of the links between natural and man-made factors and processes, understanding the drivers and barriers (in-depth interviews with stakeholders); and (3) Facilitation of understanding of the key factors influencing levels of “supply and demand” of key social and environmental benefits (focus groups of local stakeholders). The three Czech case studies were: (i) leaving forests to their natural succession in Liberec region, (ii) birds and amphibians support on wet meadows, East Bohemia, and (iii) biodiversity rich meadows in White Carpathians. Main environmental benefits focused on were biodiversity, water quality and quantity, and landscape attractiveness, main social benefits were educational and community experience. There were no strong market drivers found. Lessons learned from the study: in all cases, local NGOs were able to motivate stakeholders to support the project financially and/or by actual work. A collective action was needed both to orchestrate the support from community and public.

## PEATLANDS IN THE EU REGULATORY ENVIRONMENT – CASE STUDY FROM THE MEMBER STATES POLAND & ESTONIA

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Peatlands are Europe's largest terrestrial carbon storage and habitat for unique biodiversity but conservation and restoration efforts across Europe fall short of reaching EU's biodiversity and climate targets. Their management is influenced by EU regulations and policies in the fields of environment, agriculture and regional development. In the course of the entry of fen-rich Poland and Estonia, rich in Baltic raised bogs, into the EU in 2004, the complete EU framework became applicable at once which gives the possibility for a clear allocation of its impacts on mires. We conducted an integrative survey presenting positive and negative effects of the EU legislation and funding mechanisms on peatlands with special emphasis on the sectors nature conservation, agriculture, climate, renewable energy, structural, regional and rural development policies. The on-site effect of EU legal system and national implementation in mire-rich regions with representative peatlands within protected areas under the Natura2000 directive and used areas outside of protected zones are examined with remote sensing data and involvement of relevant stakeholders in the case studies in Poland and Estonia. We found no clear trend of land use change from remote sensing data in case studies, although in Poland disproportionately large fen areas fell abandoned after 2004. EU agricultural subsidies are the main driver of peatland management and degradation; climate issues play a neglected role so far. Incentives for large scale restoration or adapted farming like paludiculture outside of protected areas are missing, as the sectoral policy approach hinders compliance with climate and biodiversity targets to receive payments. To minimise contradicting consequences between sectors and fill regulative gaps, we drafted corresponding policy options.

# OPEN SUBMISSION

OPEN SUBMISSION 01 – SANDLIFE@SER2016

## LESSONS LEARNED IN THE RESTORATION PROJECT SAND LIFE

Gabrielle Rosquist, Maria Sandell

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Restorations of habitats on sandy soils can, quite quickly, lead to positive responses from the wild life. The creation of patches of bare sand, by opening up dense vegetation of grasses, mosses and lichens, enables a more diverse flora with many herbs, especially annuals, to develop. This improves the ecosystem by providing pollen and nectar – a basis for a richer insect, lizard and bird life. The encroached sandy habitats can be restored using different methods, from deep digging to lighter ploughing. The challenge is to keep the sand open for as long as possible – in a cost effective way. The experiences from the restorations in the Swedish Life-project “Sand Life” may be concluded in three points: (1) the localization in the landscape, (2) the design of the habitat structure, and (3) the technique used. The localization in the landscape may determine for how long the open sand will last. The life span of open sand also depends on if the restorations are made in open grasslands or in wooded sand dunes. When designing the habitat structure, it is important to consider how the open sand should be created and if it is better to create many smaller or a few larger patches. The technique and machines used must be put in relation to where the patches are created and for how long open sand can be expected to last. The cheapest way is not always the best in the long term. With this in mind, we will present lessons learned when restoring different sandy habitats in southern Sweden.

## **RESTORATION OF CALLUNA-HEATHS UNDER THE PREMISES OF FOREST CONVERSION, DRINKING WATER PRODUCTION AND COCKCHAFERS (*MELOLONTHA HIPPOCASTANI*)**

Klaus Kretschmer

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The LIFE-project “Acidophilic oak woods with bogs and heaths” (North-Rhine Westphalia) includes the restoration of a wooded area to its former status of a heath. The transformation is a typical measure which has been successfully implemented several times by the project partners. The formal forest conversion procedure has, however, resulted in several unforeseeable delays. Since the targeted area includes a small oak wood which is used by bats, the first priority was to guarantee compatibility of the forest conversion with the Habitats Directive. The area is also a drinking water production site. A layer of clay separates the floating ground water from the drinking water reservoir. The waterworks’ director had been involved in planning before the project began, but the water authorities’ concerns that the measures might damage the clay layer nearly torpedoed the entire plan. Finally, the local forestry offices worry that cockchafers may prevent long-term tree growth on the intended reforestation site. Numerous expert discussions involving external authorities led to the measure being approved in the end, on the condition that it be accompanied by stringent monitoring. The implementation is to begin late this summer. This example shows that conservation measures can fail due to unforeseeable problems in spite of good preparation, but also that good arguments and wise action can help master difficult situations on the way to achieving Natura2000 targets.

## **THE PROTECTION OF CULTURAL LANDSCAPES – THE SYRIAN CITY OF MAALOULA**

Mouaffak Doughman

*Damascus University, Faculty of Architecture, Damascus, SY, mouaffak.d@hotmail.com*

The presentation examines the case study of the archeological city of Maaloula and its natural environment. The authorities in charge of archaeological sites in the Syrian Arab Republic inscribed the city in the UNESCO provisional list in 1976, and the city together with its historic surroundings was inscribed in the same list on 8<sup>th</sup> June 1999 in compliance with the standards 5 and 6. As a result of urban expansion, and environmental and climate degradation in most of the area, the mountain chains, hills and green valley face a number of problems with respect to the invasion of an urban style that is alien to the scene both visually and naturally, a pollution of environment due to the inadequacy of infrastructures. I describe the challenge of urban and landscape planning to counteract these problems in the current, politically and economically difficult situation in Syria.

## **URBAN EXPANSION IN THE DAMASCUS REGION AND PLANS TO COUNTERACT ENVIRONMENTAL AND CLIMATE DEGRADATION**

Mouaffak Doughman

*Damascus University, Faculty of Architecture, Damascus, SY, mouaffak.d@hotmail.com*

The presentation aims at examining the evolution of the Damascus area and the classification of the major components that constitute the landscape, with a focus on its cultural, religious, aesthetic, environmental and natural characteristics. It also attempts to probe these aspects, pinpointing its major problems (mainly due to urban master plans) and its future perspective as a whole. I also present the management plans of this region and local experience with framing regulatory guidelines. I delimit the protection scope of those sites and their preservation strategies. The presentation concludes with the suggestion of some recommendations pertaining to the safeguard of the sites via domestic legislation and regulations, taking into account relevant international instruments.



# INFORMATIONS FOR PARTICIPANTS

## Instructions for oral presenters

Please hand over your presentation on a USB memory stick to the staff at our IT Desk in seminar room 2. You can pre-view the presentation there. To minimize potential incompatibilities between software versions, we recommend limited use of animation, and use of common Windows fonts for text and symbol fonts for equations.

At the start of the conference on Monday, the registration will be open from 07:30 AM onwards. In case your talk is scheduled for the first sessions on Monday, please take extra care to arrive in time. All the other presentations need to be handed over to the conference IT staff no later than the afternoon preceding the day the presentation is scheduled!

Please, arrive in your session room at least 10 min prior to the start of your session time.

## Instructions for poster presenters

Please put up your poster at registration time Monday 08:00 to 18:00. Posters should be on display from 12:00 on Monday 22 August 2016 until the end of the Conference on Thursday 25 February 2016. Posters remaining by Friday morning will be disposed of.

Posters will be allocated to the session submitted and will have an individual ID Number. The Boards will have headings according to the sessions and will be numbered and labelled with your ID. Poster pins will be supplied by the organisers.

Please attend your poster during both Monday evening poster party, and Tuesday evenings formal poster session. Be ready to give a very brief introduction of yourself and your work – session chairs are encouraged to guide 20–30 min poster tours.

## Conference name tags and vouchers

Please wear your Conference name tag in the Conference and when entering the shuttle buses and the social program. If you have bought lunch vouchers, registered to the Conference dinner and Mid-Conference excursion, the vouchers are in your Conference name tag bag.

## Mid-conference excursions

The buses take off at 8:30 at the parking lot next to the university library – the circular building next to Weihestephan bus stops. Lunch packets and drinks are included in the fee. The buses are numbered as follows:

1. Alpine forest management (Weber)
2. Floodplain forest reconstruction (Cyffka)
3. Riverbank revitalisation (Kollmann)
4. Bog regeneration (Drösler)
5. Ecology and conservation of pre-alpine lakes (Geist)
6. Quarry rehabilitation (Rademacher)
7. Calcareous grassland restoration (Kiehl)
8. Supporting agrobiodiversity in organic farming (Wiesinger)
9. Urban green infrastructure (Pauleit)

**City reception Sunday, August 21<sup>st</sup>**

The City of Freising will welcome the Conference participants in the Town Hall on Marienplatz (Central square) on Sunday evening at 19:00 hs. Refreshments will be served. Please note that there was pre-registration to this event.

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Khanchoul, Kamel	S 1-04
Kiehl, Kathrin	S 2-010; S 13-06; S 13-P2; S 19-P2; S 19-P3
Kim, Tae Wan	S 25-P2
Kirmer, Anita	S 11-09; S 21-06
Klaus, Valentin	S 13-01; S 22-P2; S 22-P3
Kleinebecker, Till	S 13-01; S 22-03; S 20-P5; S 22-P2; S 22-P3
Klimkowska, Agata	S 4-03; S 9-02; S 24-01
Köhler, Martina	S 6-03
Kollmann, Johannes	S 9-01; S 9-06; S 9-07; S 11-016; S 12-011; S 19-04; S 25-03; S 2-P1; S 9-P2; S 19-P1; S 20-P9, S 22-P6
Koop, Jochen	S 1-09
Korjus, Henn	S 7-P2; S 16-P4
Kövendi-Jakó, Anna	S 22-P4
Kozub, Łukasz	S 4-01; S 4-07; S 9-02
Krautzer, Bernhard	S 11-014; S 11-015; S 11-017
Kretschmer, Klaus	OpenS-02
Krimmer, Johann	S 11-010
Kügel, Benno	S 2-07
Kuusela, Saija	S 17-03
Laarmann, Diana	S 16-P4; S 7-P2
Lampela, Maija	S 7-09
Lang, Marion	S 19-04; S 11-07; S 11-08; S 19-P1
Lee, Yong Ho	S 25-P2
Lencova, Kamila	S 23-P3
Loy, Georg	S 1-012
Luka, Stefanie	S 2-P2
Lütt, Silke	S 11-011

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Lyngstad, Anders	S 4-06; S 21-P1; S 21-P2
Malaníková, Eli ka	S 21-08
Marcus, Mickey	S 8-07
Marcus, Julie	S 8-07
Maringer, Janet	S 5-06
Marrs, Rob	Keynote lecture; S 5-02; S 15-03; S 5-P1; S 9-P1
Martelletti, Sara	S 7-04
Melnik, Katharine	S 24-07
Memmott, Jane	Keynote lecture
Messier, François	S 26-P4
Metsoja, Jaak-Albert	S 24-09; S 21-01
Meyer, Stefan	S 19-01
Meyer, Elisabeth I.	S 1-013
Michaelis, Dierk	S 4-02
Milberg, Per	S 5-05; S 24-08; S 22-P1
Minayeva, Tatiana	S 3-06; S 3-07
Minkinen, Kari	S 3-01
Mitchley, Jonathan	S 21-09
Moeslund, Jesper Erenskjold	S 10-02
Moinardeau, Cannelle	S 6-04
Moradi, Jabbar	S 23-03; S 23-P1
Moroñ, Dawid	S 15-07
Morsing, Jonas	S 7-03; S 2-P3
Mortimer, Simon	S 21-09; S 9-P1
Müllerová, Anna	S 16-P7
Navarro -Cano, Jose Antonio	S 25-01
Nikolic, Nina	S 23-01
Nilsson, Christer	S 1-02; S 1-08; S 2-07
Ning, Zhu	S 18-01; S 7-P1
Nsikani, Mlungu	S 26-03
Nunes, Alice	S 12-08
Øien, Dag-Inge	S 4-05; S 4-06; S 21-P2
Otsuka, Noriko	S 14-03; S 14-02
Pacholik, Ewa Hanna	S 16-P3
Page-Dumroese, Deborah	S 18-04; S 18-P2
Paloniemi, Riikka	S 27-03
Pander, Joachim	S 2-09

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Paul, Carola	S 17-02
Peters, Jan	S 27-P4
Petersen, Søren O.	S 3-04
Pilotto, Francesca	S 1-08; S 1-02
Pitz, Carline	S 16-03; S 9-07
Planchuelo, Greg	S 13-05
Prach, Karel	Keynote lecture; S 12-02; S 21-07; S 16-P7
Pütz, Thomas	S 7-01
Pyke, David	S 26-04
Qian, Liyuan	S 10-05
Raman, Maud	S 22-05; S 22-02
Rasmussen, Kristine Kjørup	S 14-04
Raulund-Rasmussen, Karsten	S 7-02; S 7-03; S 2-P3
Řehouňková, Klára	S 15-01; S 12-02
Reihmanis, Jānis	S 10-P1
Rodríguez-González, Patricia María	S 2-05
Rohrer Rodríguez, Zoë	S 16-P2
Rosenthal, Gert	S 6-09
Rosquist, Gabrielle	OpenS-01
Ross, Louise	S 4-06
Rotchés-Ribalta, Roser	S 19-02
Ruffer, Janine	S 2-P2
Rupprecht, Denise	S 6-01; S 6-P1
Rusina, Solvita	S 27-P2
Rydgren, Knut	S 9-03; S 24-010
Sandell, Maria	OpenS01
Sandin, Leonard	S 1-06
Santana, Victor	S 7-08; S 5-P1
Schaumberger, Silke	S 11-014; S 11-015; S 11-017
Scheder, Christian	S 1-05
Schelfhout, Stephanie	S 22-02
Schirone, Bartolomeo	S 12-07
Schlaipfer, Martina	S 3-02
Scholz, Mathias	S 2-02
Schröder, Roland	S 13-06; S 13-P2
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Schulz, Jennifer	S 8-01

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Schwab, André	S 2-010
Sebelíková, Lenka	S 16-05
Seifert, Stefanie	S 2-P1
Séleck, Maxime	S 16-08
Shaw, Nancy	S 27-P1
Sietz, Diana	S 17-01
Silva, Carmo	S 16-02; S 16-P6
Singarayer, Florentine	S 24-08
Singh, Anand Narain	S 8-P5
Sirakaya, Aysegül	S 14-01
Sirin, Andrey	S 3-07; S 3-06
Siuda, Cornelia	S 11-04
Sliva, Jan	S 12-011
Snopek, Adam	S 16-P3
Spitoni, Marie	S 10-04
Stammel, Barbara	S 2-08
Strazdins, Girts	S 10-P1
Strobl, Katharina	S 9-01; S 9-P2
Suwanwaree, Pongthep	S 26-P3
Svavarsdóttir, Kristín	S 7-05; S 26-05
Swart, Sjaak	S 27-01
Szepesváry, Csaba	S 21-05
Tälle, Malin	S 22-P1
Teixeira, Leonardo	S 22-P6
Temperton, Vicky	S 8-06; S 22-07
Tesitel, Jakub	S 26-02
Tichanek, Filip	S 16-06; S 15-02
Tischew, Sabine	S 6-02; S 6-03; S 11-09; S 21-06; S 20-P6
Tolvanen, Anne	Keynote lecture; S 3-01; S 8-P1
Török, Katalin	S 12-05; S 22-P4; S 22-P5
Török, Péter	S 5-04; S 6-07; S 12-05; S 15-05; S 21-04; S 22-04; S 24-012; S 26-P2; S 20-P1
Tóthmérész, Béla	S 21-04; S 22-04; S 24-012; S 15-05; S 6-07; S 5-04; S 20-P1; S 26-P2
Tropek, Robert	S 15-02; S 16-06; S 23-P2
Truus, Laimdota	S 23-02; S 20-P4

Participant	Contributions
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Vidaller, Christel	S 25-04
Wagner, Markus	S 24-011; S 11-07; S 9-P1
Wagner, Viktoria	S 26-01
Walter, Jutta	S 11-05
Weber, Michael	S 17-02
Weidlich, Emanuela	S 22-07; S 8-06
Willecke, Inga	S 2-P2
Wilsey, Brian	Keynote lecture
Yuliang, Li	S 8-P4
Zauft, Michael	S 2-P2
Zaunberger, Karin	S 12-01
Zhang, Jing	S 27-06
Zhou, Ting	S 1-P4
Ziemiański, Maciej	S 13-P1
Zvingule, Laura	S 10-P1

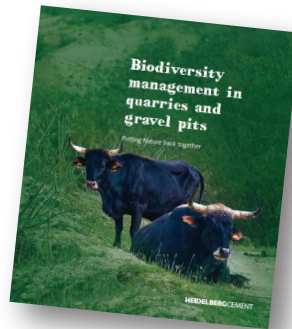


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